POTLATCH RIVER STEELHEAD MONITORING AND EVALUATION PROJECT

Annual Report
2010

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ABSTRACT

Objectives of the Potlatch River Steelhead Monitoring and Evaluation (PRSME) project are to establish baseline levels of steelhead trout *Oncorhynchus mykiss* production and productivity and provide an umbrella monitoring component to the numerous habitat restoration projects currently occurring within the drainage. In 2008, the project expanded the monitoring effort into both the upper and lower Potlatch River drainages. This expanded effort was continued in 2010. A total of 373 adult steelhead were captured and handled at PRSME weir sites during the 2010 field season. Two-hundred fifty two and 71 unique steelhead were captured at the lower and upper drainage weirs respectively. Mark-recapture occurrences resulted in adult steelhead escapement estimates of 251 (95% CI 213-298) and 71 (95% CI 39-120) spawners in the Big Bear and East Fork Potlatch River drainages. Adult escapement estimates for 2010 were higher in Big Bear Creek and similar in the East Fork Potlatch River to adult escapement estimates for the drainages from previous years. Radio-telemetry detections within the Big Bear Creek drainage showed a limited spawning distribution during the 2010 field season with 75% of detections radio-tagged females occurring within two km of the weir. Mark-recapture juvenile steelhead trapping at screw traps on Big Bear Creek and the East Fork Potlatch River during the 2010 field season resulted in out-migration estimates of 9,764 (95% CI, 8,833-10,837) and 32,502 (95% CI, 27,891-38,559) at the two sites respectively. Smolt arrival estimates to Lower Granite Dam were 54% and 8% respectively from Big Bear Creek and the East Fork Potlatch River screw traps. We tagged 1,230 juvenile steelhead across the entire Potlatch River drainage. Subsequent detections from these fish will provide valuable insight into juvenile movements and over summer habitat use and survival at a tributary level. A total of 79 snorkel sites were sampled throughout the Potlatch River drainage during the 2010 field season. Steelhead densities, predominately juveniles (age-1 and age-2) and fry (age-0) for the entire drainage were 1.35 and 0.14 fish / 100 m^2 respectively (SE = 1.02 and 0.55). Juvenile steelhead densities were highest within the Big Bear Creek drainage with 3.72 fish/100 m^2. Freshwater productivity estimates in juvenile recruits/female spawner within the Big Bear Creek drainage have ranged from 62.3 – 269.9 for brood years 2005 – 2008. The Potlatch River Steelhead Monitoring and Evaluation Project continues to expand our knowledge of steelhead within the Potlatch River drainage as well as provide insights for the lower main stem Clearwater River steelhead population.

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INTRODUCTION

The Potlatch River Steelhead Monitoring and Evaluation (PRSME) project was initiated in 2005 using Pacific Coastal Salmon Recovery Funds. In 2008, the project was expanded into the upper Potlatch River watershed using National Oceanic and Atmospheric Administration (NOAA) Fisheries Intensively Monitored Watershed Funds. The additional funds allowed work to occur simultaneously throughout the entire drainage. The expanded project in 2008 was initiated to assess steelhead production and productivity throughout the entire Potlatch River drainage.

The Potlatch River likely has the strongest component of wild steelhead present within the Clearwater River lower main stem population (Bowersox et al. 2008). The Interior Columbia River Technical Recovery Team (ICTRT) estimated that the Potlatch River drainage contains one major spawning aggregation (Upper Potlatch River; including Big Bear Creek and East Fork Potlatch River) and two minor spawning aggregations (Middle Potlatch Creek and Little Potlatch Creek)(NOAA Draft Recovery Plan 2006). They estimated that the Potlatch River drainage comprises 25% of the historic intrinsic potential of the Clearwater River lower main stem steelhead population (NOAA Draft Recovery Plan 2006). The lower Clearwater River steelhead population is important to steelhead recovery; however no information was available regarding population production and productivity. This project was designed to establish baseline indices regarding population dynamics and expand the knowledge of steelhead life history strategies within the Potlatch River and the lower Clearwater River as a whole.

The Potlatch River is a drainage that has undergone significant amounts of change over the past 150 years. Land practices and manipulation associated with agricultural use and timber harvest have significantly altered the aquatic habitats present within the drainage as well as flow dynamics associated with the hydrograph. These changes have resulted in a variety of limiting factors identified by previous work (Johnson 1985; Bowersox and Brindza 2006) within the drainage. These limiting factors include:

1) Extreme flow variation,
2) High summer water temperatures,
3) Lack of riparian habitat,
4) High sediment loads, and
5) Low densities of in-stream structure.

Despite the significantly altered condition of aquatic habitats within the Potlatch River drainage, it does support an important population of wild steelhead trout. Aside from general distribution and abundance data (Schriever and Nelson 1999; Bowersox and Brindza 2006) limited information was available with regards to levels of productivity, production, and life history strategies for steelhead in the Potlatch River drainage.

Potlatch River steelhead are genetically distinct from other Clearwater River steelhead groups such as Dworshak hatchery strain steelhead (Byrne 2005). The geographic location of the drainage and lack of hatchery influence within Potlatch River steelhead make understanding population dynamics of this group extremely important regarding recovery actions for Clearwater River steelhead (ICTRT 2003).

In recent years, the Potlatch River has received additional focus from governmental and non-governmental agencies regarding its restoration potential. The Latah Country Soil and

Water Conservation District, Idaho Department of Fish and Game (IDFG), Natural Resource Conservation Service (NRCS), and the U.S. Forest Service (USFS) have begun significant restoration efforts throughout the drainage. The goal of the ongoing Pacific Coastal Salmon Recovery Funds (PCSRF) project is to determine steelhead population response (production and productivity) to habitat enhancement.

This study is designed to provide baseline information on steelhead within the Potlatch River drainage as well as an umbrella monitoring component to habitat restoration projects being implemented within the drainage. The framework needs to be adaptive as well as rigid. It needs to be capable of shifting with monitoring needs as well as being able to detect steelhead production and productivity changes within the Potlatch River.

This report contains results from 2010 which was the sixth field season for the monitoring and evaluation effort in the lower drainage and the third field season in the upper drainage. Field activities included adult escapement estimation, juvenile out-migration estimates, juvenile survival estimates, in-stream density estimates, habitat surveys, adult telemetry surveys, and juvenile summer movement surveys.

OBJECTIVES

1) Establish baseline levels of steelhead production and productivity throughout the Potlatch River drainage.

2) Provide a monitoring component to the numerous habitat restoration projects currently ongoing within the Potlatch River drainage.

3) Describe steelhead life history strategies exhibited within the Potlatch River drainage.

STUDY AREA

The Potlatch River drainage is located in Latah, Nez Perce, and Clearwater counties. The main stem Potlatch River is 89.4 km long and has a total drainage area of 152,621 ha (Department of Agriculture 1994). The drainage is approximately 78% private ownership (Schriever and Nelson 1999). The lower watershed, which includes the Big Bear drainage, is dominated almost entirely by private ownership while the upper watershed, which includes the East Fork Potlatch River drainage, has two dominate landowners, Potlatch Timber Corporation and the USFS (Figure 1). Dominant land use and land type differ between the two drainage areas. The lower drainage is dominated by agricultural use and agricultural uplands and canyon bottomlands while the upper drainage is dominated by timberland and timberland ecotypes (Bowersox and Brindza 2006). Intensively monitored tributaries are Big Bear Creek and the East Fork Potlatch River drainages (Figure 1). The bulk of monitoring infrastructure is located in these drainages (Appendix A).

Mean daily stream discharge measured at the U.S. Geologic Survey (USGS) flow site (13341570) approximately 5 out-migrations above the mouth of the Potlatch River, ranged from 2,050 to 16 cfs during the 2010 trapping season (Figure 2). Stream flows exceeded 1,000 cfs for 8 days during the 2010 adult trapping season (Figure 2). Stream temperature, as measured at the Big Bear Creek screw trap, during the spring trapping season ranged from a low of 2°C early in the season to a high of 16°C in early summer when the flows became too low to run the trap.

METHODS

Adult Sampling

Picket weirs were constructed to capture upstream migrating adult steelhead on January 27th and January 23rd at Big Bear and Little Bear Creeks, respectively (Appendix 1). Initially, weirs were outfitted with only an upstream migrant trap box. Both weirs were maintained and checked for fish daily. Weirs were not operational due to ice and high flows for 7 days at Little Bear and 3 days Big Bear Creek weirs during the spring trapping season.

Floating weirs were constructed to captured upstream migrating adult steelhead on February 26th and March 10th at the East and West Fork Potlatch River, respectively (Appendix 1). Initially, weirs were outfitted with only an upstream migrant trap box. Both weirs were maintained and checked for fish daily. The East Fork Potlatch River and West Fork Potlatch River weirs remained operational for the entire trapping season, although kelt captures were limited during some high flow events.

Trapped upstream migrants at all traps were collected from the trap box and anesthetized in MS-222. Upstream fish were marked with a right operculum punch and passive integrated transponder (PIT) tagged in the left cheek. Returning fish marked with PIT tags as juveniles were FLOY tagged at the base of the dorsal fin in case the PIT tag was shed upon spawning. Radio telemetry tags were placed in a sub-sample of adult female steelhead at each weir. The gender, weight, length, and the presence of any marks were recorded for all fish handled. All wild upstream migrants were released above the weir. Hatchery fish captured at the weirs were relocated below the weir. Traps were pulled after adult steelhead kelt out-migration was complete.

Downstream trap boxes were installed at lower weir locations by March 9th and by April 14th at upper weir locations. Crowding techniques using nets and temporary barriers were also used at all weir locations to capture additional kelts within 100 m of the upstream side of the weir. Fish captured in the downstream box or by net were given a left operculum punch, PIT tagged if not already captured and released immediately downstream of the weir. Gender, weight, length, the presence of a previous operculum punch and/or PIT tag was recorded for all fish captured.

Total adult escapement above the weirs was calculated using a maximum likelihood estimator (Steinhorst et al., 2004) using the variables of total kelt steelhead captured during the trapping season, marked adults passed upstream and number of marked adults recaptured as kelts. Assumptions required are that marked and unmarked adults had the same survival during spawning and individual fish are captured independently with equal probability.

Scale samples were collected from all unique adult fish captured during the 2010 field season. Scales were collected posterior to the dorsal fin above the lateral line. Three or four scales were taken from each side of the fish. Scales were stored on Rite-in-Rain paper inside scale envelopes. The scale samples were sent to the IDFG Fisheries Research Aging Laboratory in Nampa and processed using protocols outlined in Ellsworth and Ackerman (2011).

In order to identify spawning reaches and assess fish passage at Big Bear Falls a subsample of upstream migrating female steelhead that were captured at Potlatch River weirs were gastrointestinal radio-tagged using Lotek Model MCFT2-3A tags (Frequency 149.280). Fish were selected across the run based upon weekly captures of upstream females arriving at the weir. No retention structures such as rubber bands and/or bards were used with the tags to increase the likelihood of removal of the tag post-spawn. The objective was to tag 10 females above each weir therefore tags were deployed throughout the upstream migration. Females were radio-tracked on a bi-weekly basis during the spawning migration using a Lotek Model SRX 600 receiver. Tracking was done on foot, ATV, and truck on both Big Bear Creek drainage and the Upper Potlatch River (above the East Fork and West Fork Potlatch River weirs). When tags were located the time, strength of signal, GPS position and whether or not the fish was actually observed were recorded. We also recorded if redd building and/or a completed redd was observed at the site. When fish were recaptured as kelts at the downstream weirs the tags were removed and the fish was released downstream of the weir untagged. Some tags were able to be reused in multiple females.

Juvenile Sampling

A rotary screw trap was operated on Big Bear Creek and the East Fork Potlatch River during the 2010 field season (Appendix 1). The Big Bear Creek trap was located approximately 250 m from the confluence with the Potlatch River and below the confluence of Big Bear and Little Bear Creeks. Therefore, the screw trap estimated total juvenile steelhead emigration out of both Big Bear and Little Bear Creeks and their tributaries. The East Fork Potlatch River screw trap was located approximately 300 m above its confluence with the main stem Potlatch River. Screw traps were checked daily throughout the spring and fall trapping seasons. Spring trapping was conducted on Big Bear Creek from February 16th – July 3rd and February 25th – July 11th at the East Fork Potlatch River during the spring outmigration. The traps were no longer operational by early July at both sites due to insufficient flows. The traps were also operated in the fall from December 13th – December 31st at the Big Bear Creek site and from October 27th – November 17th at the East Fork Potlatch River site. During sampling periods, trapping was only interrupted due to extremely high or low stream discharge. All fish captured at the screw traps were identified and enumerated. In addition, sub-samples, the first ten encountered each day, of non-target species were weighed and measured. All steelhead were weighed, measured, and scanned for the presence of PIT tags. Juvenile steelhead (>75 mm) not previously tagged were anesthetized using MS-222 solution and tagged in the abdomen with a PIT tag following PIT tagging best practice procedures (Columbia Basin Fish and Wildlife Authority 1999). All PIT tagged individuals were allowed to recover in live wells and were then released approximately 500 m upstream of the screw trap to estimate trapping efficiency. Tag files were created within the P3 PIT tag data management program and uploaded to the PTAGIS (www.psmfc.org) database daily.

Total juvenile steelhead out-migration from Big Bear Creek and the East Fork Potlatch River was estimated using Gauss software, specifically the Bailey modified maximum likelihood method developed by Steinhorst et al. (2004). The trapping season was divided into periods based upon trapping efficiency for each trap. A running average of weekly trapping efficiency was plotted in order to determine appropriate out-migration periods. Trapping days were grouped based upon periods of similar recapture probability. Input variables included; number of marked (PIT tagged) fish released upstream for recapture, number of marked fish recaptured, and the number of unmarked fish captured. Assumptions required for the use of this method are that all fish, marked and unmarked, are captured independently with the same probability during each period. Juvenile outmigrant survival to Lower Granite Dam was estimated using PitPro 4.18 software (Westhagen and Skaliski 2010).

A total of 294 and 251 scales were randomly sampled from the out-migrating juveniles collected at the screw trap on Big Bear Creek and the East Fork Potlatch River, respectively. Every fifth fish had scales taken in order to spread samples out over the entire juvenile out-migration. Scales were sampled posterior to the dorsal fin above the lateral line. Scales were stored on Rite-in-Rain paper inside scale envelopes. The scale samples were sent to the IDFG Fisheries Research Aging Laboratory in Nampa and processed using protocols outlined in Ellsworth and Ackerman (2011).

Juvenile Steelhead Summer Surveys

To estimate juvenile in-stream survival in the lower Potlatch River tributaries, juvenile steelhead/rainbow trout were PIT tagged throughout the drainage during the 2008-2009 field seasons. Fly-fishing and backpack electroshocking were conducted at various locations throughout the tributaries to collect fish for PIT tagging. We attempted to distribute tags relative to juvenile steelhead abundance within an individual tributary. All juvenile steelhead/rainbow trout, >75 mm, were anesthetized in MS-222, measured, weighed, and PIT tagged. The PIT tag data was uploaded to the PTAGIS database on a daily basis. Detections at the main stem Potlatch River Juliaetta array and Lower Granite Dam will be used to estimate in-stream survival in from those tag groups during the 2010 out-migration.

Additional roving tagging was conducted throughout the lower Potlatch River basin from June 1^{st} through July 28^{th} during the 2010 field season. During this timeframe fish were tagged early or late in the day to ensure water temperatures did not exceed the 18^{oC} maximum tagging temperature threshold as required by NOAA. Fish were captured using hook and line as well as backpack electrofishing techniques. Tagging areas were distributed across the known steelhead distribution within tagging tributaries. Fish were released in close proximity to their place of capture within their respective tributaries. Over summer survival information from these release groups will be included in the 2011 PRSME Annual Report.

To monitor over summer movement in the Big Bear Creek drainage (Big Bear Creek, Little Bear Creek, and West Fork Little Bear Creek) in 2010, juvenile steelhead/rainbow trout were PIT tagged in early summer and subsequently interrogated with PIT packs at three intervals during the remainder of summer and into the fall (July 12^{th} – 22^{nd}, August 30^{th} – September 16^{th} and October 18^{th} – 21^{st}). Fish were captured for PIT tagging using fly-fishing and electroshocking. PIT tagged fish were interrogated using Destron Fearing FS2001 readers and antenna wands constructed by Biomark. Systems were powered by a 12V battery and tuned using Biomark tuning box. The entire steelhead distribution of Big Bear Creek drainage was sampled and scanned for PIT tags. Sampling methods were similar to backpack electrofishing. Surveyors worked upstream thoroughly covering the entire stream channel sweeping the antenna attempting to interrogated tags. In larger pools, one surveyor attempted to “herd” fish past the antenna being held in the water column by the other surveyor. When a fish was interrogated during the surveys, the PIT tag number, habitat type, GPS location, time, and water temperature was recorded. Dissolved oxygen was also recorded at each interrogation site using an YSI Model ProODO reader. When a PIT tag was interrogated, it was also important to determine if it was a shed tag or in a live fish. When a fish was observed the time of interrogation was also recorded. If an interrogated PIT tag was stationary in the stream sediment surveyors attempted to recover the tag. If the tag was recovered or the tag remained stationary during the attempted excavation it was labeled as a shed tag. The PIT tag data was uploaded to the PTAGIS database as passive observation data.

Mark-resight snorkel surveys were conducted throughout Potlatch River tributaries during the 2010 field season. Sample sites were selected using a generalized random-tessellation stratification design to provide a spatially balanced panel of survey sites (Stevens and Olsen 2004). Potential sites for the Potlatch River basin were obtained from personnel at the US-EPA, Corvallis, Oregon. Mark-resight snorkeling protocols were consistent with techniques outlined in Copeland et al. (2008). A minimum of 20 sites were completed in Big Bear Creek and the East Fork Potlatch River drainages to provide enough statistical power to track changes in juvenile steelhead density over time. This sample size was generated by conducting a power analysis on 2008 snorkel data from the Potlatch River drainage.

PIT Tag Arrays

Three instream PIT tag arrays were operated during the 2010 field season. All three arrays are arranged in an upstream and downstream antenna array configuration. One array was located on Big Bear Creek (Big Bear Creek array), and two arrays were located on the main stem Potlatch River, one near Juliaetta, ID (Juliaetta array), and one near Helmer, ID (Helmer array). Big Bear Creek array was located approximately 250 meters upstream of the confluence with the main stem Potlatch River. The Big Bear Creek array was operated with six PVC antennas for most of the field season. Both the upstream and downstream arrays spanned the channel width. The PVC antennas were constructed by IDFG personnel out of the Clearwater Region. The Juliaetta and Helmer arrays were manufactured as a flat panel design by Biomark, Inc. of Boise Idaho. The Juliaetta array was located approximately 13km upstream of the confluence of the Clearwater River, consisting of three upstream and three downstream antennas. All antennas were twenty feet in width for a total array width of sixty feet. The Helmer array was located approximately 500 m downstream of the confluence of the East Fork and West Fork Potlatch Rivers, at RKM 61. This array consisted of four flat panel antennas, two twenty feet and two ten feet antennas. All array sites were registered with the Columbia River Basin PTAGIS database, as in-stream interrogation sites. All data collected from the sites was uploaded to the PTAGIS database on a semi-monthly basis. All issues such as power outages and antenna failures encountered with each array were documented in the Site Event Logs on the PTAGIS Operations and Maintenance Website (http://www.ptoccentral.org).

Efficiency Estimates

To determine the performance of in-stream PIT tag arrays, detections of PIT tagged fish were used to generate an estimate of detection efficiency for all life stages of steelhead PIT tagged by the PRSME project (Appendix F). Detection efficiency is the percentage of PIT tagged fish that were detected when and if they passed interrogation systems (Connolly et al. 2008). We used the two array detection probability model in the USER program (Lady et al. 2009) to calculate the detection efficiency of migrating juvenile, adult, and kelt steelhead. Each individual's life stage is determined by the direction of travel over the arrays coupled with the age of the individual fish. Detection efficiencies were produced across the entire sample season for each migrant life stage.

Fish that displayed a milling and/or resident behavior over the antennas caused a need to create a set of rules for defining life stage migration through observation data. Detection events were filtered and grouped accordingly, based upon the following criteria:

- All life stages: If a subsequent detection occurs 24 hours after the first detection(s), it was considered a separate event.
- Juveniles: Select the last unique, downstream detection event. Use the timing associated with captures at screw traps and the detections at other arrays. Juvenile fish

that appear to display a resident life history with multiple upstream and downstream events are excluded from the juvenile detection efficiency estimate.

- Adults: Select the last unique, upstream event before estimated spawning time. Use the timing associated with the detections at other antennas and weirs (peak days at LBW and PEW were 3/31/10 and 4/17/10 with 45 fish and 23 fish respectively) as well as adult migration timing to determine spawning time.
- Kelts: Select the last unique, downstream event after estimated spawning time. Use the timing associated with the detections at other antennas and weirs as well as adult migration timing to determine spawning time.

Reach Based Survival/Arrival Methods

PIT tag interrogation data from instream arrays and dam passage facilities of fish tagged in the spring of 2010 at screw traps located on Big Bear Creek and the East Fork Potlatch River were used to estimate juvenile arrival rates to the Juliaetta array and Lower Granite Dam using PitPro 4.18 (Westhagen and Skaliski 2009). Juvenile fish captured at screw traps were assumed to be actively migrating out of their natal tributary. Subsequent interrogations at downstream arrays and within the hydrosystem were used to determine smolting rates and downstream rearing reaches for the Big Bear Creek and East Fork Potlatch River tag groups.

PIT tag interrogation data from instream arrays and dam passage facilities of fish tagged in the summer of 2009 were used to estimate juvenile survival to the spring of 2010 to the Juliaetta array and Lower Granite Dam from tributaries of the Lower Potlatch River with PitPro 4.18 (Westhagen and Skaliski 2009). One major assumption when comparing survival rates between tributaries was that equal rates of residency occurred within the group of tributaries sampled. Major tributaries that were sampled during 2009 roving tagging include: Pine Creek, Cedar Creek, Corral Creek, Big Bear Creek, Little Bear Creek, and West Fork Little Bear Creek.

PIT tag interrogation data from instream arrays and dam passage facilities were used to estimate reach based survival and travel rates of kelts with PitPro 4.18 (Westhagen and Skaliski 2009). Kelts from the East Fork Potlatch River and West Fork Potlatch River weirs were combined to form an upper drainage group, and kelts from Little Bear Creek and Big Bear Creek weirs were combined to form a lower drainage group. The upper drainage group was also supplemented with detections at Helmer array from PIT tagged kelts not captured at the weirs. Travel time for this supplemented group was not available due to the lack of a release time and date at their respective weir locations. Survival was estimated from release to each of the interrogation sites downstream of release location (destination survival) as well as intermediate survival from one interrogation site to the next (reach survival).

Habitat Surveys

Low Water Habitat Availability Protocol (LWHAP) surveys were conducted to estimate and evaluate wetted habitat quality present within lower Potlatch River tributaries. Transects were walked August 4th – 9^{th,} 2010. Tributaries were stratified into upland and canyon reaches to disperse transects throughout each tributary. Two randomly selected 500 m transects were walked within each strata and in each tributary (Appendix G) resulting in four transects surveyed per tributary. The length of wetted habitat and the number of pools was recorded within each transect. In addition to wetted habitat, pool availability and quality we also measured the maximum depth, modal depth, pool length, pool width, and whether or not salmonids were present (visual observation) for all pools within the transect.

Freshwater Productivity

Freshwater productivity estimates in juvenile recruits/female spawner have been estimated for brood years 2005-2008 on the Big Bear Creek drainage and brood year 2008 on the East Fork Potlatch River drainage. These estimates were derived by estimating annual adult escapement and applying the observed sex ratio at each weir to the estimate to establish the number of annual female spawners. This estimate was then divided by the subsequent year's juvenile out-migrants at the associated juvenile fish screw trap on that drainage. Age classes of the out-migration are established through scale analysis. The number of female spawners estimated by each brood year was then divided by the total juvenile out-migration for that brood year to estimate juvenile recruits/female spawner.

RESULTS

Adult Abundance and Migration Timing

A total of 373 unique adult steelhead were captured during the 2010 field season. Of these fish, 252 were captured at lower drainage weirs (Big Bear and Little Bear) and 121 were captured at upper drainage weirs (East and West Fork). Results for the lower drainage weirs will be combined in this section of the report. Results for the upper drainage weirs will be reported separately due to the location of the screw trap being on the East Fork Potlatch River upstream of its confluence with the West Fork Potlatch River.

A total of 252 unique adult steelhead were captured at the lower Potlatch River weirs during the 2010 trapping season. Of these, 251 were captured and marked as upstream pre-spawn migrants. One-hundred thirty five adult steelhead were captured as downstream post-spawn migrants; 134 of these fish were recaptures. The mark-recapture occurrences resulted in an adult steelhead escapement estimate into the Big Bear drainage (Big Bear and Little Bear Creeks) of 251 (95% CI 213 – 298) fish.

The first upstream spawner arrived at the lower weirs on February 17th at Little Bear Creek (Figure 3). Fifty percent of the run was passed upstream by March 30st and the final upstream spawner arrived at the lower weirs on April 28th (Figure 3). The first downstream post-spawn kelt arrived at the lower weirs on March 18th ; fifty percent and final kelt arrival occurred on April 17th and April 20th , respectively (Figure 3).

A total of 71 unique steelhead were captured at the East Fork Potlatch River weir during the 2010 field season. Of these, 70 were captured and marked as upstream pre-spawn migrants. Twenty adult steelhead were captured and released downstream as post-spawn migrants; 19 of these were recaptures. This resulted in an adult steelhead escapement estimate of 71 (95% CI 39 – 120) into the East Fork Potlatch River.

A total of 50 unique adult steelhead were captured at the West Fork Potlatch River weir during the 2010 field season; all of which were captured and marked as upstream pre-spawn migrants. Twenty adult steelhead were captured as downstream post-spawn migrants; all 20 of these were recaptures. This resulted in an adult steelhead escapement estimate of 49 (95% CI 28 – 77) into the West Fork Potlatch River.

The first upstream spawner arrived at the upper weirs on March 26th at the West Fork Potlatch River weir (Figure 4). Fifty percent of the run was passed upstream by April 18th and the final upstream spawner arrived at the upper weirs on May 11th (Figure 4). The first downstream post-spawn kelt arrived at the upper weirs on April 10th; fifty percent and final kelt arrival occurred on April 25th and May 21st , respectively (Figure 4).

Radio-telemetry

A total of twenty-eight unique adult pre-spawn steelhead were tagged at the four weir sites in 2010. Sixteen and thirteen radio tags were deployed at the lower and upper weirs sites, respectively. Because of tracking limitations and logistical issues in the upper Potlatch River drainage results from that drainage are not reported. The furthest documented spawning migration of an adult female steelhead was 10.52 km upstream of the Little Bear Creek weir into the West Fork of Little Bear Creek. Seventy-five percent of the detections in Little Bear Creek occurred within 2.0 km of the weir (Figure 5). The furthest documented spawning migration in Big Bear Creek was 9.56 km above the weir and was located at the base of Big Bear Creek Falls, a potential migration barrier. The average number of days fish spent above the weirs before returning as kelts was 23 days (SE = 1.99). There were seven steelhead redds documented while radio-tracking during the Spring of 2010 above adult steelhead weirs (Figure 6). Four redds were documented in the lower basin with active spawning occurring on three of them, including a single redd at the base of Big Bear Creek Falls.

Adult Life History Characteristics

Female steelhead captured at lower drainage weirs ranged in length from 539 – 775 mm and males ranged from 516 - 871 mm (Table 1). Female steelhead captured in the upper drainage ranged from 542 – 792 mm and males ranged from 574 – 845 mm (Table 1).

Total unique captures of males and females were 102 and 150 at lower weirs and 42 and 79 at upper weirs, respectively. The observed sex ratios of females per males from the 2010 field season was 1.5 and 2 for lower and upper weirs, respectively. The observed ratios differ significantly (Chi-square a < 0.01) from the expected ratio of 1:1. The estimated number of fish by sex comprising the 2010 run was 100 and 150 fish in the lower drainage and 42 and 79 in the upper drainage for males and females, respectively The fact that the estimated number of fish is almost identical to the actual number of fish captured is due to the operation of near census weirs in 2010. Water conditions and trap modifications played a significant role in our extremely efficient trapping.

Scale samples were taken from 373 adult steelhead captured during the 2010 field season. Scale samples from 332 fish were assigned freshwater and ocean ages. Thirty-seven fish were unable to be assigned freshwater ages because of regeneration and 4 fish were unageable entirely. Scale analysis displayed a variety of freshwater and ocean life history strategies being utilized within the population (Figure 7). The 2-Fresh 2-Ocean and 2-Fresh 1-Ocean life histories were the most prevalent with 41 and 47% of the fish sampled displaying these strategies at the upper and lower weirs respectively (Figure 7). Freshwater residency ranged from 1-3 years and adult ocean residency was 1-2 years (Figure 7).

A total of twenty-one steelhead tagged in the Potlatch River Basin as juveniles in 2005, 2007, and 2008 returned to the Columbia River Basin as upstream adult migrants based on observations at dam passage facilities and in-stream array detections (Appendix B). Twenty were detected at Bonneville Dam during the summer of 2009 (Appendix B). Sixteen fish were subsequently detected passing Lower Granite and thirteen were detected passing the Juliaetta array later in the migration (Appendix B). Four fish detected at Bonneville were not detected at Lower Granite (Appendix B). One fish detected at Lower Granite was not detected at Bonneville (Appendix B). The first upstream adult was detected at Bonneville Dam on July 24th, 2009, and the last detection was September 10th, 2009 (Appendix B). The first upstream adult was detected at Lower Granite Dam September 4th, 2009, and the last detection was March 22th, 2010 (Appendix B). Mean travel time from Bonneville Dam to Lower Granite Dam was 61.1 days and mean travel time from Lower Granite Dam to the Juliaetta array was 154.5 days (Appendix B). Ocean life histories included eight 1-oceans, and ten 2-oceans, of the eighteen known ocean age returning adults. Three steelhead were tagged in the Potlatch River Basin as juveniles but were not detected during their juvenile out-migration, therefore the duration of their ocean life history is uncertain.

Kelt Out-migration Survival

Of 135 Big Bear Creek kelts 81 were detected at Big Bear Creek array, 67 at Juliaetta array, and 7 at or below Lower Granite Dam in the hydropower system. Upper Potlatch River kelts were observed at Helmer array and Juliaetta array with 24 and 6 unique detections respectively with none observed at Lower Granite Dam. Kelt survival from Big Bear Creek to Juliaetta array was 62.4%, while Upper Potlatch River kelts survived at 21.7%. Destination survival for Big Bear Creek kelts from weirs to Big Bear Creek array, to Juliaetta array and to Lower Granite Dam was 70.3%, 62.4% and 9.4% respectively (Table 2). Destination survival of kelts from Upper Potlatch River weirs to Helmer array and to Juliaetta array were 72.7% and 18.2% respectively (Table 2). Destination survival for Upper Potlatch River kelts from weirs to Lower Granite Dam could not be estimated due to a lack of detections. Reach survival for kelts from Big Bear Creek weirs to Big Bear Creek array was 70.3%, Big Bear array to Juliaetta array was 88.7%, and Juliaetta array to Lower Granite Dam was 15.2% (Table 3). Reach survival for kelts from Upper Potlatch River weirs to Helmer array was 72.7% and Helmer array to Juliaetta array was 25.0% (Table 3). Estimated kelt travel time for the Big Bear Creek release group was 1.1 days from Big Bear Creek weirs to Big Bear Creek array, 2.2 days (4.9 km/day) from Big Bear Creek array to Juliaetta array, and 11.0 days (10.2 km/day) Lower Granite Dam. Estimated kelt travel time from Upper Potlatch River release group was 0.5 days from weirs to Helmer array, and 4.8 days (12.7 km day) from the Helmer array to the Juliaetta array. Kelt travel rates from weirs to associated tributary arrays was not computed since both Big Bear Creek and the upper Potlatch River have two different release sites. Travel time and rate of Upper Potlatch River kelts to Lower Granite Dam could not be estimated due to low sample size.

Juvenile Emigration

Juvenile Out-migrant Estimates

The rotary screw trap on Big Bear Creek was operated during the spring trapping season from February 16th until July 3rd, 2010. During this period, the trap operated a total of 115 days. A total of 2,081 unique steelhead were captured, 1,827 of which were PIT tagged and released above the trap. Of these, 393 were recaptured. The trapping season was subsequently grouped into five periods with different trapping efficiencies (Table 4). An estimated 9,764 juveniles emigrated during the spring of 2010 from the Big Bear Creek system (95% CI 8,833 – 10,837)(Table 4). In addition, the rotary screw trap was also operated during the fall for 12 days from December 13th - 31st. A total of 49 juvenile steelhead were captured, 49 of which were PIT tagged. Of these, 12 were recaptured. All fish were grouped into one trapping period with a trap efficiency of 0.24. (Table 5). We estimated 189 juvenile steelhead out-migrated from Big Bear Creek during this brief fall trapping period (95% CI 109 – 342) (Table 5).

The rotary screw trap on the East Fork Potlatch River was operated from February 25th until July 11th, 2010. During this period, the trap operated a total of 132 days. A total of 2856 unique steelhead were captured, 2110 of which were PIT tagged and released above the trap. Of these, 196 were recaptured. The trapping season was subsequently grouped into three periods with different trapping efficiencies (Table 6). An estimated 32,502 juveniles emigrated from the East Fork Potlatch River system (95% CI 27,891 – 38,559) (Table 6). In addition, the rotary screw trap was also operated for 21 days between October 27th and November 17th for a total of 21 nights. A total of 327 unique steelhead were captured. Of these, 231 were sub-taggable (>75 mm). Ninety-six were PIT tagged and released above the trap. Of these, 16 were recaptured. All fish were grouped into one trapping period with a trap efficiency of 0.17 (Table 7). We estimated 1,866 juvenile steelhead out-migrated from the East Fork Potlatch River during the fall trapping season.

Length and Age Distributions

Steelhead sampled from Big Bear Creek screw trap had a larger size distribution than those sampled at East Fork Potlatch River screw trap (Figure 8). Juvenile steelhead captured at Big Bear Creek and the East Fork Potlatch River ranged from 57 - 242 mm and 67 - 193 mm, respectively. Mean length of steelhead sampled was 162.3 mm on Big Bear Creek and 103.6 mm on the East Fork Potlatch River. Scales were taken off 294 and 251 juvenile steelhead at Big Bear Creek and East Fork Potlatch screw traps, respectively during the 2010 spring out-migration. The dominant age class represented was age-2 (62%) at Big Bear Creek and age-1 (75%) at the East Fork Potlatch River (Figure 9). Length distribution of known age individuals was also larger for fish sampled at Big Bear Creek compared to the East Fork Potlatch River (Figure 10). Overall, Big Bear Creek fish were older and larger than East Fork Potlatch River fish when emigrating from their natal tributary.

Smolt Out-migrant Arrival Rates

A total of 585 juvenile steelhead tagged at Potlatch River screw traps during the spring 2010 out-migration were detected in the hydrosystem Lower Granite Dam and downstream (522-Big Bear and 63-East Fork Potlatch). Smolt arrival estimate to Lower Granite Dam from Big Bear Creek and the East Fork Potlatch was 54% and 8% respectively (SE 0.04 and 0.01). Capture probability for Big Bear Creek and the East Fork Potlatch River at Lower Granite Dam was 22% and 28% respectively (SE 0.02 and 0.06). Out-migrating smolts from Big Bear Creek were observed at Lower Granite Dam April 29th – June 5th and April 28th – June 6th for out-migrating smolts from East Fork Potlatch River.

Smolt Out-migration /Juvenile Rearing Strategies

Unique fish detections of juvenile steelhead PIT tagged at Big Bear Creek and East Fork Potlatch River screw traps during 2010 were detected in the hydrosystem at 98 and 35% respectively during the 2010 out-migration (Table 8). Additional unique detections in the hydrosystem from each release group occurred the following year in 2011. Data from 2008-2010 shows 70-98% of Big Bear Creek juveniles are detected downstream in the hydrosystem during the same year as tagging while 65-70% of East Fork Potlatch River juveniles are detected in subsequent years post tagging (Table 8). Emigration rates out of natal tributaries the same year as tagging are similar for both release groups with 94 and 91% of juveniles being detected at downstream tributary PIT tag arrays near the mouths of Big Bear Creek and the East Fork Potlatch River, respectively (Table 9). Emigration rates from release sites to the main stem Potlatch River PIT tag array site are different with arrival rates of 78% for the Big Bear Creek release group and 18% of East Fork Potlatch River release group arriving the same year as tagging (Table 9). Reach based survival estimates are different in the tributary PIT tag array to Main stem PIT tag array reach with 82% and 20% of Big Bear Creek and East Fork Potlatch River release groups surviving this reach, respectively (Table 10). Survival from the main stem Potlatch River PIT tag array to Lower Granite Dam was similar for both release groups with 62 and 46% of fish passing the main stem PIT-array reaching Lower Granite Dam from Big Bear Creek and the East Fork Potlatch River respectively (Table 10).

2009 Roving Tagged Fish Survival

A total of 2,415 fish were tagged in the 2009 field season, during annual roving tagging efforts. Overall survival probability for fish tagged in tributary streams during the 2009 field season to Lower Granite Dam during the 2010 out-migration season was 0.16 (SE 0.02). Individual tributary survival probabilities to the Juliaetta array ranged from 0.34 (SE 0.16) – 0.08 (SE 0.03) in Cedar Creek and Corral Creek, respectively (Table 11). The West Fork Little Bear Creek had the second lowest summer survival to Juliaetta array with only 0.10 (SE 0.02) arrival to that site (Table 11). Tributary to Lower Granite Dam survival ranged from a high of 0.15 (SE 0.07) in Pine Creek to a low of 0.10 (SE 0.03) in the West Fork of Little Bear Creek (Table 11). Similar to findings in 2009, the West Fork of Little Bear Creek continues to have poor survival to locations downstream in the drainage and Lower Granite Dam.

2010 Roving Tagging

A total of 1230 fish were captured and PIT tagged during the 2010 roving tagging effort. Of these, 1076 fish were tagged in the Big Bear Creek drainage and 151 fish in the East Fork Potlatch River (Table 12). Estimates on run timing and over summer survival will become available as these fish outmigrate past Lower Granite dam during the spring of 2011.

PIT-Pack Surveys

Juvenile steelhead were PIT tagged in May and June throughout the Big Bear Creek drainage in proportion to juvenile densities within each area of the drainage (Figure 11). The number of tagged steelhead in each area of the drainage ranged from 529 in the West Fork of Little Bear Creek to 43 in Schwartz Creek (Table 12). Tag interrogation distributions on each pass are displayed in Appendix C, D, and E). Juvenile steelhead movement (km) from initial tagging location to detection location was measured for 152 individual fish. Three fish were unable to be used in the analysis because of inaccurate GPS locations. Movement ranged from a maximum 12.6 km to a minimum .005 km, with the mean distance 0.59 ± 0.13 km. The majority of fish (60.4%) were detected within 0.25 km of their original tagging location (Figure 12). While 10.7% of fish were detected > 1.0 km from their original tagging location, remaining fish moved between 0.25 km and 1.0 km from their original tagging location (Figure 12). Fish movement was limited to within the tributary it was initially tagged in, except for three unique cases where individuals moved down in the drainage (i.e. Little Bear Creek to Lower Big Bear Creek). Sixteen fish were detected two times. Because we measured the distance of movement as a straight line between two GPS locations (i.e. initial tagging and detection locations) and did not account for bends in the stream, these should be considered conservative estimates of fish movement. We hypothesized that fish movement may be related to size. However, our data suggests that fish movement and size are unrelated (Figure 13; ANOVA R^2 = $2.2x10^{-4}$, F =.029, P=0.86).

Snorkel Surveys

Snorkel surveys were conducted June 12^{th} – 19^{th} during the 2010 field season. A total of 79 snorkel sites were sampled throughout the Potlatch River drainage. All sites were randomly selected using the Environmental Monitoring and Assessment Program (EMAP) protocol. Juvenile (age-1 and age-2) and fry (age-0) steelhead densities for the entire Potlatch River drainage were 1.35 and 0.14 fish / 100 m^2, respectively (SE = 0.21 and 0.03) (Table 13). Juvenile steelhead densities were highest within the East Fork Big Bear Creek drainage with 6.34 fish / 100 m^2 being observed (Table 13). Sample sites within the entire Big Bear Creek drainage had an average density of 2.54 fish / 100m^2 (Table 13).

Snorkeling conditions in 2010 were more challenging than in previous years. Visibility was limited at most sites throughout the drainage due to a spring rain storm. As a result, the snorkels crews were unable to observe and identify the fishes to a specific species, therefore there were several trout and fry observations documented as various species (Table 13). Overall, steelhead showed a wide distribution across most suitable habitat present within the Potlatch River drainage.

Low Water Habitat Surveys

Low water habitat availability surveys conducted during the 2010 field season estimated 77% of stream channel within the lower Potlatch River basin was wetted during the first week in August. Corral Creek had the lowest average percentage wetted habitat of the tributaries with only 37% wetted habitat at the survey sites (Appendix G). The West Fork Little Bear Creek and Little Bear Creek had the highest percentage of wetted habitat with 100 and 98 % wetted, respectively (Appendix G). Corral Creek had the lowest pool density with 0.75 pools/100 m^2 and Cedar Creek had the highest pool density with 3.55 pools/100 m^2 (Appendix G). Overall percent wetted habitat was similar to the two previous years with 79.3 and 73 % wetted channel in 2009 and 2008 respectively. Sample year 2007 had the lowest percent wetted habitat within the sampled tributaries with 54 % wetted channel.

Brood Year Productivity

Complete brood year productivity estimates in juveniles / spawner have been generated for three brood years on the Big Bear Creek drainage. Juveniles / spawner estimates have ranged from 62.3 in brood year 2005 up to 269.9 in brood year 2006 (Table 14). A partial (missing age-3) estimate has been generated for brood year 2008 with 158.0 juveniles / spawner (Table 14). Initial productivity estimates for Big Bear Creek fit a density-dependent relationship based upon limited habitat for juvenile rearing (Figure 14).

Given the later start date for adult trapping on the East Fork Potlatch River (2008) we have only generated two partial brood year productivity estimate for that population. The partial estimate (age-3) for brood year 2008 is 356.6 juveniles/spawner and the partial estimate for brood year 2009 is 602.2 juveniles/spawner (Table 9). The estimates for the East Fork Potlatch River group are not directly comparable with regards to active smolt outmigrants/spawner within the Big Bear Creek drainage since we have documented significant differences in juvenile life history between the two groups.

DISCUSSION

Steelhead productivity in the Big Bear Creek drainage appears to be highly density dependent. The juvenile recruits per female spawner productivity estimates for BY 2005 – 2008 show a sharp decline in productivity as female escapement into the drainage increases. The presence of density-dependent effects has been well documented in salmonid populations. Achord et al. (2003) found Chinook parr survival to be negatively related with initial density. Survival from rearing tributary to Lower Granite Dam of Chinook juveniles found in high initial density streams was half that of fish found in low density streams (Achord et al. 2003). Elliot (1994) found that brown trout survival was negatively correlated with initial egg density in Black Brows Beck, England. He also found loss rates of brown trout in various life stages to be highly density-dependent (Elliot 1994). We believe that the Big Bear Creek drainage and the rest of the Lower Potlatch River and associated tributaries are extremely stream flow limited by mid to late summer. This lack of late summer rearing habitat would negatively impact steelhead production in these systems by limiting rearing habitat. As stream flow conditions improve we expect productivity in juvenile recruits per female spawner to also improve. Habitat restoration efforts in the Lower Potlatch River should be focused on stream flow improvement and/or allowing access to additional stream habitat through barrier removal.

Differences in juvenile life history strategies between the upper and lower Potlatch River drainage release groups will have significant affects estimating annual smolt out-migration and brood year smolt production for both Big Bear Creek and the East Fork Potlatch River. Since most juvenile fish emigrating from the Big Bear Creek drainage are in fact smolts, the typical same year survival to Lower Granite Dam analysis is largely unbiased. In a release group such as the East Fork Potlatch River, where most individuals are rearing additional time downstream prior to smolt out-migration, a more complex survival model is needed to account for subsequent year's mortality prior to smoltification and out-migration downstream. Life history variation in steelhead populations and delayed juvenile out-migration has been documented by numerous studies (Ward and Slaney 1988, Maher and Larkin 1955, Chapman 1958, and Peven et al. 1994). Therefore, steelhead researchers, including PSRME staff, have been working with Columbia Basin Research (CBR), University of Washington, staff at developing such a model. The new model will incorporate an approach outlined in Lowther and Skalski (1998). CBR staff is currently working on developing a statistical program for non-statistician fisheries researchers similar to SURPH (Lady et al. 2001).

Based upon our survival analysis of the 2010 screw trap release group, East Fork Potlatch River juveniles appear to be rearing a subsequent year between the Upper Potlatch River PIT tag array and the main stem Potlatch River PIT tag array. Our findings are similar to Leider et al (1986) who found that many juvenile steelhead would emigrate from Gobar Creek to the main stem Kalama River and rear an additional year prior to smoltification and ocean out-migration while others would rear entirely within the tributary. Hayes et al. (2008) also found differences in juvenile steelhead rearing strategies in Scott Creek, California. They found three different rearing strategies exhibited: upper-watershed, estuary-lagoon, and combined upper-watershed and estuary lagoon rearing (Hayes et al. 2008). In this instance, the estuary-lagoon may serve a similar ecological function to that of a main stem river. It is important to understand the specifics of the East Fork Potlatch River steelhead life history strategies so that not only monitoring efforts can account for differences in survival and productivity related to life history strategies but also so that habitat restoration efforts can be appropriately identified and prioritized for this group.

Kelt survival from the Potlatch River drainage appears to be very low even though repeat spawning has been documented in previous years release groups. Kelt out-migration survival from Potlatch River adult steelhead weirs to Lower Granite Dam was low during the 2010 field season. Work conducted by Narum et al. (2008) agreed with our findings with only 0.8% of kelts sampled at Lower Granite Dam assigning back to the East Fork Potlatch River group. However, Potlatch River kelts may be underrepresented in this study since Big Bear Creek fish were not included in the study. We believe lower Potlatch River fish will comprise the greatest number of kelts moving out of the drainage. However, it is unlikely that Potlatch River kelts survive at high rates to complete a second spawning migration.

Steelhead released as part of the Potlatch River Steelhead Monitoring Project will provide a valuable tool in evaluating the effects of surface spill at hydroelectric facilities on the success of kelt out-migration and survival. Currently, annual repeat spawning estimates for the Snake River basin range from 0.5 – 1.2% (Keefer et al. 2008). However, it is widely believed that retrofitting hydroelectric facilities with surface spill capabilities will increase steelhead kelt survival and decrease steelhead kelt migration passage time back to the Columbia River estuary. Wertheimer (2007) found forebay residence time of radio-tagged kelts was much lower post installation of surface bypass at one powerhouse on Bonneville Dam compared to kelt passage times prior to surface spill. He also found that non-turbine kelt passage increased with over 80% of kelts in the study passing via surface flow (Wertheimer 2007). The PRSME project has been tagging adult steelhead at weirs since 2005 and 2008 at Big Bear Creek drainage and the East Fork Potlatch River respectively. As surface spill facilities come online throughout the hydrosystem both historic and current data on migration timing, passage time of kelts, and the occurrence of repeat spawning within the Potlatch River will provide valuable insight on these infrastructure manipulations.

The radio-telemetry data from Big Bear Creek drainage showed a concentrated spatial distribution of steelhead spawning. Low spring streamflow during steelhead spawning may affect the spatial distribution of spawning redds. Mean daily stream flow on the main stem Potlatch River gage exceeded 1,000 cfs for seven days during the adult spawning season (February 1 – June 1) in 2010. In comparison, mean daily stream flow on the main stem Potlatch River gage exceeded 1,000 cfs for 58 and 61 days during the same timeframe in 2009 and 2008 respectively. Overwhelmingly, steelhead spawning was documented within canyon reaches of the drainage and often within 2-5 km of the weir, even when additional spawning habitat was upstream. We observed three radio-tagged females conducting redd building activities on the same gravel bar within the West Fork of Little Bear Creek suggesting limited spawning habitat availability. Streamflow regulates not only the amount of suitable spawning habitat available but also the locations of suitable spawning habitats (Bjornn and Reiser 1991). It is likely that low streamflow in the Potlatch River greatly reduce available steelhead spawning habitat not only through reducing wetted widths within specific reaches available to adult steelhead spawners but also by linearly reducing the stream length available to adult steelhead because of shallow water depths restricting movement to headwater reaches (Bjornn and Reiser 1991). Additional work during higher flow years will enable us to document if spawning distribution expands higher in the drainage under higher spring streamflow.

The extent of the steelhead spawning distribution will affect habitat restoration efforts and potential easement acquisitions within the Big Bear Creek drainage and elsewhere in the Potlatch River drainage. Based upon our 2010 findings we see value in protecting canyon reaches of Potlatch River tributaries not only for rearing habitat but also spawning habitat. Prior to our telemetry work we believe most of the spawning occurred in higher reaches and juveniles then migrated into canyon reaches for rearing. Based upon our telemetry findings most if not all of this year's spawning occurred in lower canyon reaches of the Big Bear drainage. Future years of telemetry data during higher streamflow will enable us to determine how the spatial distribution of spawning changes from year to year.

Radio-telemetry efforts in the upper Potlatch River basin were largely unsuccessful during the 2010 field season. Captures of adult female spawners was successful and did allow for an adequate number of tags to be deployed. However, tracking conditions in the upper Potlatch River are much different than the Big Bear Creek drainage. Access points for ground tracking are limited in many areas of the upper Potlatch River and the drainage area is much larger than Big Bear Creek. If a radio-telemetry project is attempted in the upper Potlatch River drainage again we recommend only tagging fish at the East Fork Potlatch River weir and incorporating aerial tracking into the study design. This would allow the effort to be concentrated on a manageable drainage area and increased detections in more remote reaches.

Low spring stream flows during steelhead spawning appeared to delay spawn timing in the Big Bear Creek drainage. The peak in adult steelhead spawning was approximately one month later than in previous years of the study and coincided with the only substantial increase in stream discharge that we experience during the 2010 trapping season. Salmonid spawning is affected by both water temperatures and stream flow (Bjornn and Reiser 1991). In 2010, the main influence on steelhead spawn timing in the Big Bear drainage appeared to be streamflow. Over 50% of the upstream migrants were captured in a three day period associated with an increase in streamflow from 260 to 968 cfs on the main stem Potlatch River gauge (USGS 2010). In spawning years with adequate streamflow we believe that spawn timing will be influenced by water temperature similar to other studies found within the literature (Graham and Orth 1986, Carscadden et al. 1997, and Burger et al. 1985).

PIT-Pack survey data showed limited juvenile steelhead movement or purposeful migration within the Big Bear Creek drainage. We propose two potential explanation for this: 1) adequate hyporehic flow and suitable rearing habitat although, limited already exists throughout the canyon reaches of the drainage, or 2) mid-late summer flows are limiting to the extent that juvenile movement is restricted and fish are "trapped" in arbitrary rearing locations. Micro-habitat selection by juvenile *O. mykiss* has been documented in the literature. In Rancheria Creek, California, Neilsen et al. (1994) observed movement of juvenile steelhead trout from main stem holding habitat to intra-gravel feed cooler pools when stream temperatures rose above 22^{o}C. However, in other study streams they did not observe movement or increases in juvenile steelhead density within cooler pools even with ambient surface water temperatures of 24^{o}C and they suggested low dissolved oxygen content from groundwater seeps may outweigh the benefits of lower temperatures in some situations (Neilsen et al. 1994). Matthews and Berg (1997) documented water temperature, dissolved oxygen and fish distribution in two study pools within Sespe Creek, California. They observed rainbow trout selecting for cold water habitat during high temperature and low flow periods in the cooler of the two study pools (Matthews and Berg 1997). They also observed fish migration from or mortality in a warmer pool with an average surface water temperature of 27.9 ^{o}C (Matthews and Berg 1997). If fish in the Big Bear Creek drainage are using short (>50 m) daily movements to seek thermal refugia we would not be able to detect it using our PIT-pack protocol. However, large scale movements (< 1 km) were not observed suggesting juvenile steelhead trout distribution does not shift in the drainage from early to late summer.

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Table 1. Length distributions for male and female upstream spawners captured at lower and upper Potlatch River, Idaho weirs during the 2010 field season.

Location	**Sex**	**N**	**Min Length (mm)**	**Max Length (mm)**	**Average Length (mm)**	**SD**	**SE**
Lower Weirs	Female	149	539	775	682.16	58.41	4.79
Lower Weirs	Male	103	516	871	658.35	73.06	7.23
Upper Weirs	Female	77	542	792	674.63	61.59	7.02
Upper Weirs	Male	41	574	845	688.78	78.82	12.32

Table 2. Kelt destination survival estimates from release at weirs on Big Bear Creek drainage and the East Fork Potlatch River, Idaho to downstream interrogation sites during the 2010 kelt out-migration.

	Destination Survival		
Sample Group	Tributary Array	Main stem Array	Lower Granite Dam
Big Bear Creek	0.70 (SE 0.04)	0.62 (SE 0.12)	0.09 (SE 0.07)
East Fork Potlatch	0.73 (SE 0.08)	0.18 (SE 0.07)	N/A

Table 3. Kelt reach based survival estimates from release at weirs on Big Bear Creek drainage and the East Fork Potlatch River, Idaho to associated tributary interrogation sites and between downstream interrogation sites during the 2010 kelt out-migration.

	Reach Survival		
Sample Group	Tributary Array	Main stem Array	Dam Interrogation Site
Big Bear Creek	0.70 (SE 0.04)	0.88 (SE 0.16)	0.15 (SE 0.11)
East Fork Potlatch	0.73 (SE 0.08)	0.25 (SE 0.09)	N/A

Table 4. Numbers of juvenile steelhead captured, marked and recaptured at the Big Bear Creek, Idaho, screw trap including five single period out-migrant estimates and the total out-migration estimate for the 2010 spring trapping season. Also included is average trap efficiency, migrant estimate, 95% confidence intervals (CI) and standard error (SE) for each sample period.

Dates	Captured	Marked	Recaptured	Efficiency	Migrant Estimate	Lower 95% CI	Upper 95% CI	SE
3/17 - 4/25	326	322	60	0.19	1726	1373	2224	226.8
4/26 - 5/2	442	442	89	0.2	2176	1796	2681	232.3
5/3 - 5/29	1128	882	220	0.25	4507	3968	5127	288.4
5/30 - 6/6	124	124	14	0.11	1033	625	1804	309.4
6/7 - 6/30	61	57	10	0.18	322	178	570	100.6
Total	2081	1827	393	0.18	9764	8833	10837	516.4

Table 5. Numbers of juvenile steelhead captured, marked, recaptured, and resulting migrant estimate for Big Bear Creek, Idaho, screw trap during the 2010 fall trapping season. Also included is average trap efficiency, migrant estimate, 95% confidence intervals (CI) and standard error (SE) for each sample period.

Dates	**Captured**	**Marked**	**Recaptured**	**Efficiency**	**Migrant Estimate**	**Lower 95% CI**	**Upper 95% CI**	**SE**
12/13 - 12/27	49	49	12	0.24	189	109	342	58.4

Table 6. Numbers of juvenile steelhead captured, marked and recaptured at the East Fork Potlatch River, Idaho, screw trap including three single period out-migrant estimates and the total out-migration estimate for the 2010 spring trapping season. Also included is average trap efficiency, migrant estimate, 95% confidence intervals (CI) and standard error (SE) for each sample period.

Dates	Captured	Marked	Recaptured	Efficiency	Migrant Estimate	Lower 95% CI	Upper 95% CI	SE
3/12 - 4/15	486	285	28	0.1	4793	3432	6721	858.6
4/16 - 5/10	1507	1091	126	0.12	12958	11042	15347	1106.3
5/11 - 7/3	863	734	42	0.06	14751	11050	20075	2324
Total	2856	2110	196	0.09	32502	27891	38559	2636.8

Table 7. Numbers of juvenile steelhead captured, marked, recaptured, and resulting migrant estimate for the East Fork Potlatch River, Idaho, screw trap during the 2010 fall trapping season. Also included is average trap efficiency, migrant estimate, 95% confidence intervals (CI) and standard error (SE) for each sample period.

Dates	Captured	Marked	Recaptured	Efficiency	Migrant Estimate	Lower 95% CI	Upper 95% CI	SE
10/27 - 11/17	327	96	16	0.17	1866	1261	3056	472.4

Table 8. Number of juvenile steelhead tagged by tag year at Big Bear Creek (BIGBEC and the East Fork Potlatch River (POTEF), Idaho screw traps with subsequent detections in the Columbia River hydropower system (Lower Granite Dam and downstream). Percent of the total number of detections for a tagging year is shown beside number of unique detections for each detection year. All detections represent unique individual fish detections (i.e. a fish detected at Lower Granite Dam will have subsequent downstream detections removed from record).

				n / Detection Year			
Trap	**Tag Year**	**Number Tagged**	**Number Detected**	**2008**	**2009**	**2010**	**2011**
BIGBEC	2008	1064	433	306 (70%)	127 (30%)		
	2009	973	330		302 (92%)	28 (8%)	
	2010	1827	622			610 (98%)	12 (2%)
POTREF	2008	422	102	36 (35%)	63 (62%)	3 (3%)	
	2009	1287	128		39 (30%)	73 (57%)	16 (13%)
	2010	2110	308			109 (35%)	199 (65%)

Table 9. The destination survival (from release site to each individual interrogation site downstream for juvenile steelhead released at screw traps on Big Bear Creek and the East Fork Potlatch River, Idaho during the 2010 field season.

Release Site	Destination Survival Tributary Array	 Main stem Array	 Lower Granite
Big Bear Creek	0.94 (SE 0.02)	0.78 (SE 0.05)	0.54 (0.04)
East Fork Potlatch	0.91 (SE 0.08)	0.18 (SE 0.05)	0.08 (SE 0.01)

Table 10. The reach survival from release site to the first downstream interrogation site and between subsequent interrogation sites downstream for juvenile steelhead released at screw traps on Big Bear Creek and the East Fork Potlatch River, Idaho during the 2010 field season.

Sample Group	Reach Survival Tributary Array	 Main stem Array	 Dam Interrogation Site
Big Bear Creek	0.94 (SE 0.02)	0.82 (SE 0.05)	0.62 (SE 0.07)
East Fork Potlatch	0.91 (SE 0.08)	0.20 (SE 0.05)	0.46 (SE 0.13)

Table 11. Summary table of survival probabilities to Juliaetta array and Lower Granite Dam for fish tagged in Potlatch River, Idaho, tributaries during the summer of 2009. Detection data was queried from the 2010 out-migration season. N/A represents tag groups with insufficient interrogations for arrival estimation.

Stream	n	Arrival to JUL (SE)	Arrival to LWG (SE)
Pine Creek	613	0.17 (0.05)	0.15 (0.07)
Cedar Creek	535	0.34 (0.16)	0.11 (0.03)
Corral Creek	238	0.08 (0.03)	N/A
Little Bear Creek	341	0.22 (0.09)	N/A
WF Little Bear Creek	499	0.10 (0.02)	0.10 (0.03)
Big Bear Creek	189	N/A	N/A
Big Bear Drainage	1029	0.14 (0.04)	0.12 (0.05)

Table 12. Number of juvenile steelhead/rainbow trout PIT tagged in tributaries of the Potlatch River, Idaho during roving tagging in 2010.

Stream	# of fish tagged
Big Bear Creek	209
Schwartz Creek	43
Little Bear Creek	298
West Fork Little Bear Creek	529
East Fork Potlatch River	151
Total	1230

Table 13. Snorkel survey salmonid density summary data from sites snorkeled in the Potlatch River watershed, Idaho, from June 12th through the 19th, 2010. Non-salmonid presence was recorded during surveys but is not reported on this table.

Stream	Sites (n)	Steelhead (O. mykiss)	Salmonid (Var. Species)	Fry (Oncorhynchus var. species)	Brook trout
Big Bear Creek	8	1.09	0.02	0.46	0
Big Meadow Creek	1	0	0	0	0
Bloom Creek	2	2.17	0	0	0.79
Bob's Creek	5	0.44	0	0	5.58
Dry Creek	2	0	0	0	0
E.F. Big Bear Creek	2	6.34	0	0	0
E.F. Potlatch River	24	1.07	0.16	0.06	0.6
Fry Creek	1	0	0	0	0
Howell Creek	1	0	0	0	0
Jackson Creek	2	5.41	0	0	1.7
Little Bear Creek	5	3.2	0.46	0.71	0
M.F. Big Bear Creek	2	0.18	0	0	0
Nora Creek	1	0	0	0	0
Potlatch River	5	0.46	0.02	0.05	0.37
Randall Flat Creek	2	0	0	0	0
Ruby Creek	4	2.32	0	0.43	0.35
Schwartz Creek	3	1.48	0	0.5	0
Spring Valley Creek	1	3.83	0	0	0
W.F. Big Bear Creek	3	0	0	0	0
W.F. Little Bear Creek	4	0.41	0.4	0.57	0
W.F. Potlatch River	1	0	0	0.13	0
Overall Average	**3.76**	**1.35**	**0.05**	**0.14**	**0.45**

Table 14. Estimate of brood year productivity in juvenile steelhead out-migrants / female spawner in Big Bear Creek and East Fork Potlatch River, Idaho.

Drainage	BY	Adult Escapement Estimate	Proportion Female	# female spawners	Juvenile Out-migration				Total BY Production	Juveniles/ Spawner
					Age -0	Age-1	Age-2	Age-3		
Big Bear	2005	214	0.72	154.08	0	3091.22	6414.00	87.10	9592.32	62.255446
Big Bear	2006	57	0.4	22.8	0	2740.00	2496.73	916.56	6153.29	269.88098
Big Bear	2007	108	0.74	79.92	0	2903.17	4175.42	199	7277.60	91.061024
Big Bear	2008	121	0.39	47	0	1256.02	6171	*	7427.02	158.02173
Big Bear	2009	135	0.45	61.3	0	3583	*	*		
Big Bear	2010	251	0.6	150.6	0	*	*	*		
East Fork	2008	140	0.36	50.4	583	9486	7905	*	17974	356.62683
East Fork	2009	92	0.46	42.8	0	25776	*	*	25776	602.24299
East Fork	2010	71	0.81	56.7	0	*	*	*	*	*

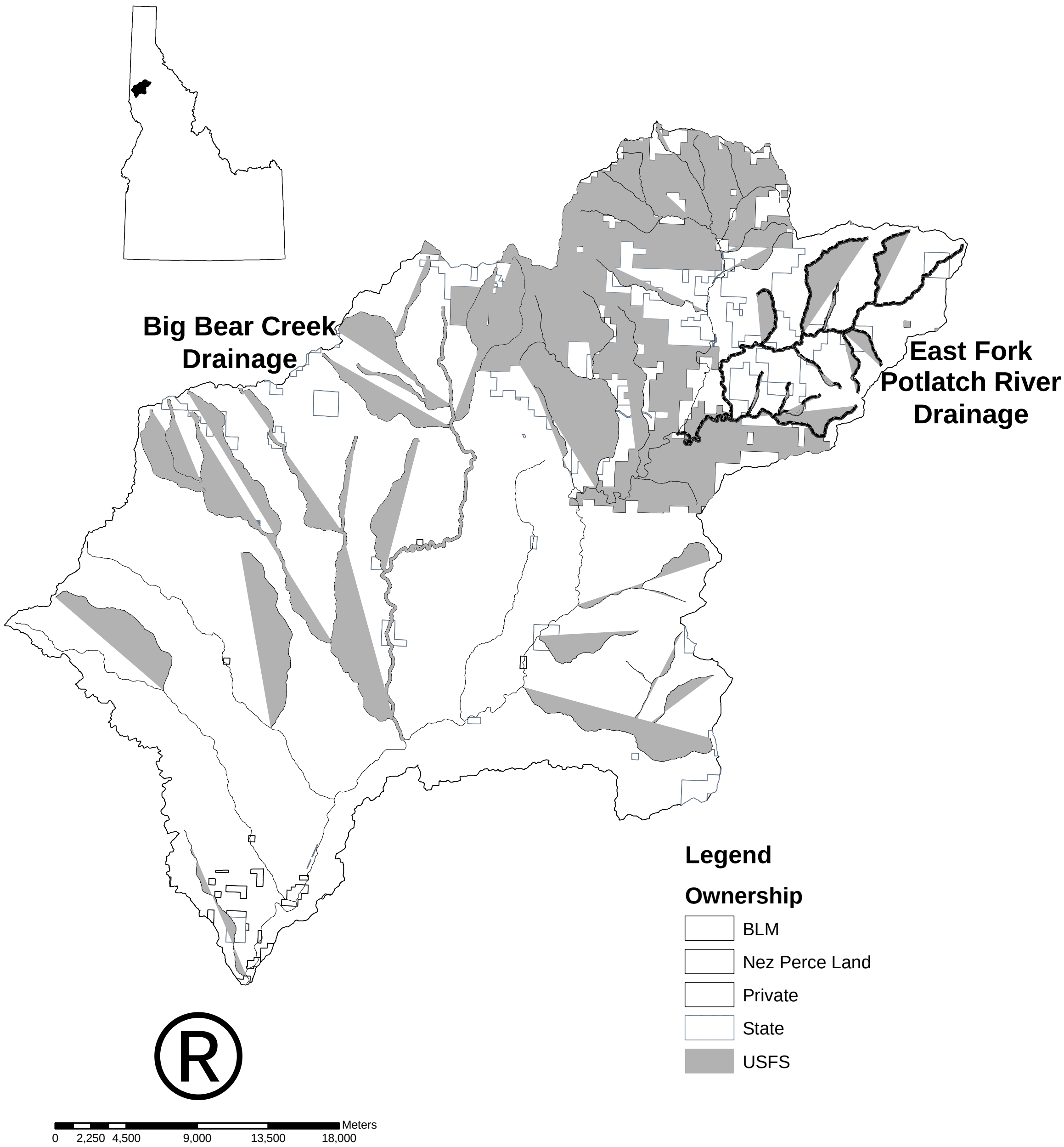


Figure 1. Potlatch River drainage, Idaho, with intensively monitored tributaries, Big Bear and East Fork Potlatch River, highlighted in lower and upper portion of the drainage.

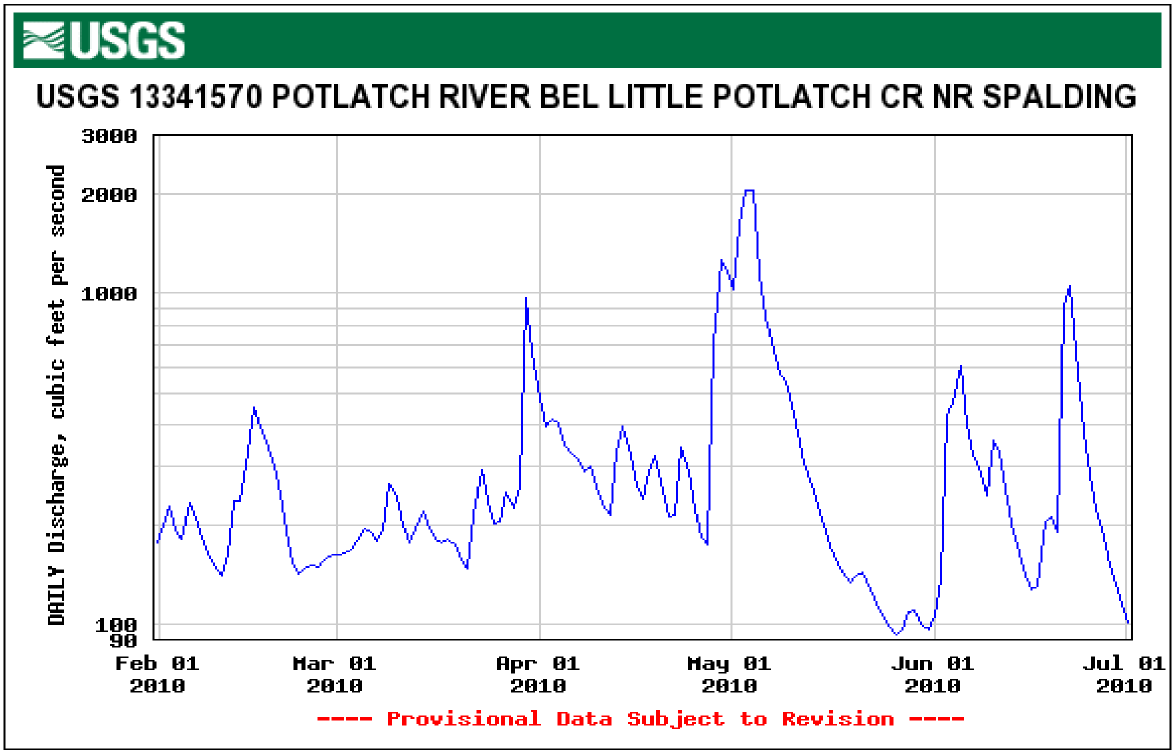


Figure 2. Daily mean discharge of main stem Potlatch River, Idaho, recorded during the 2010 adult steelhead trapping season.

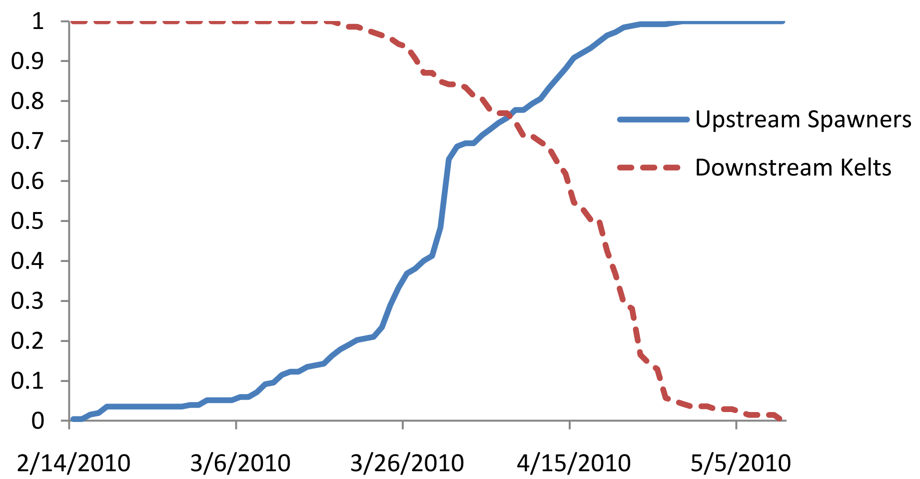


Figure 3. Spawning migration timing of adult steelhead, pre and post spawn, captured at Big Bear Creek drainage, Idaho, weirs during the 2010 trapping season.

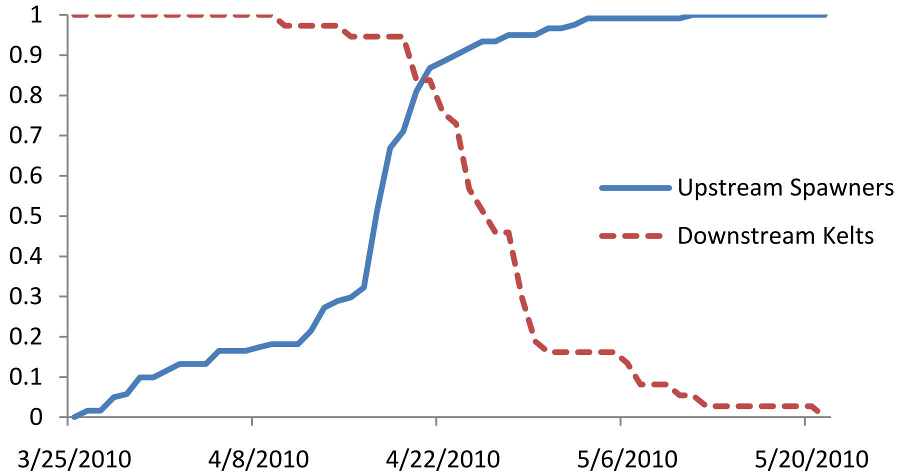


Figure 4. Spawning migration timing of adult steelhead, pre and post spawn, captured at upper Potlatch River drainage, Idaho, weirs during the 2010 trapping season.

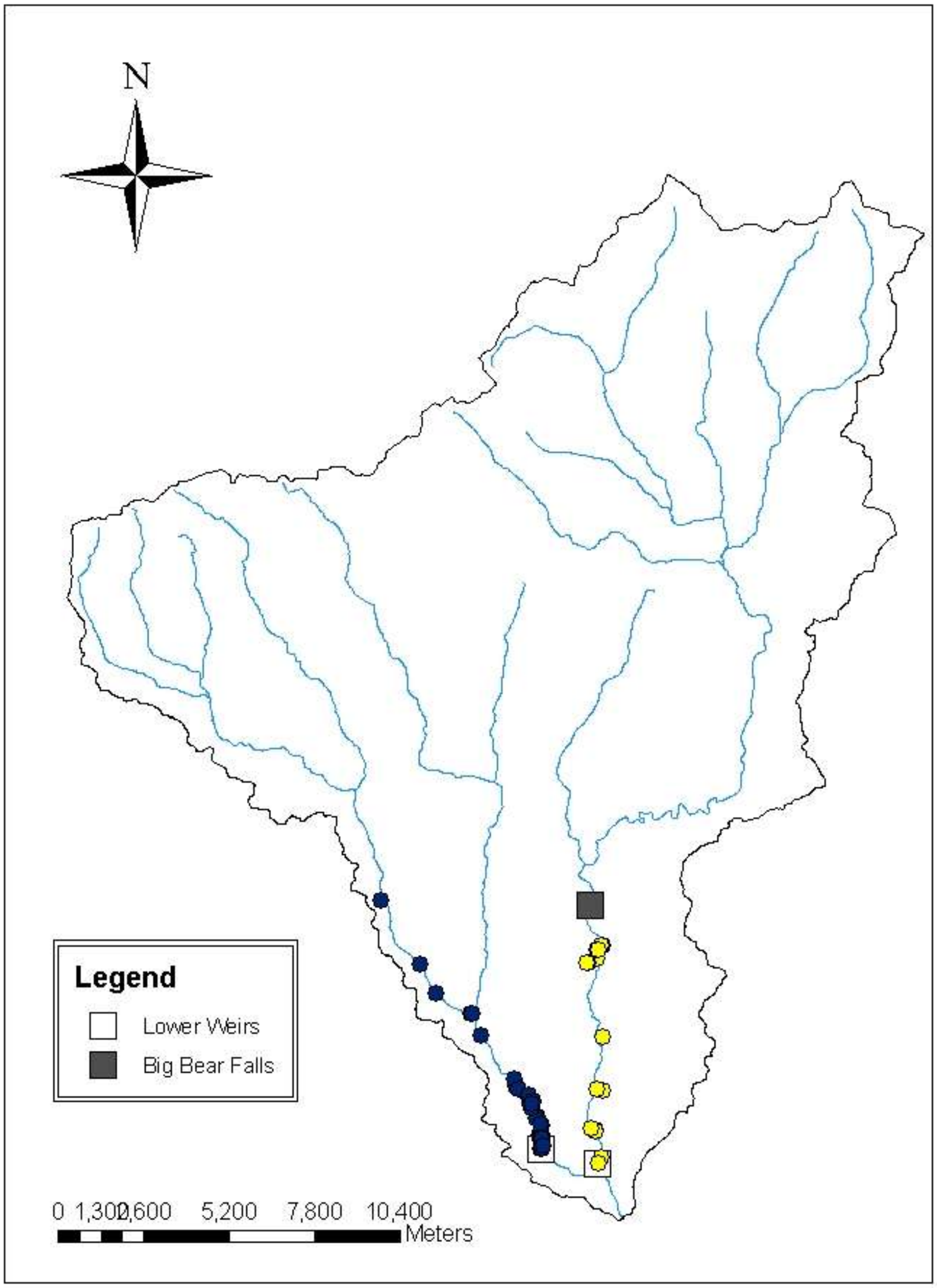


Figure 5. Map of Big Bear Creek drainage, Idaho with all detection sites of female spawners during the 2010 spawning migration. Big Bear Creek detections shown in yellow and Little Bear Creek detections shown in blue.

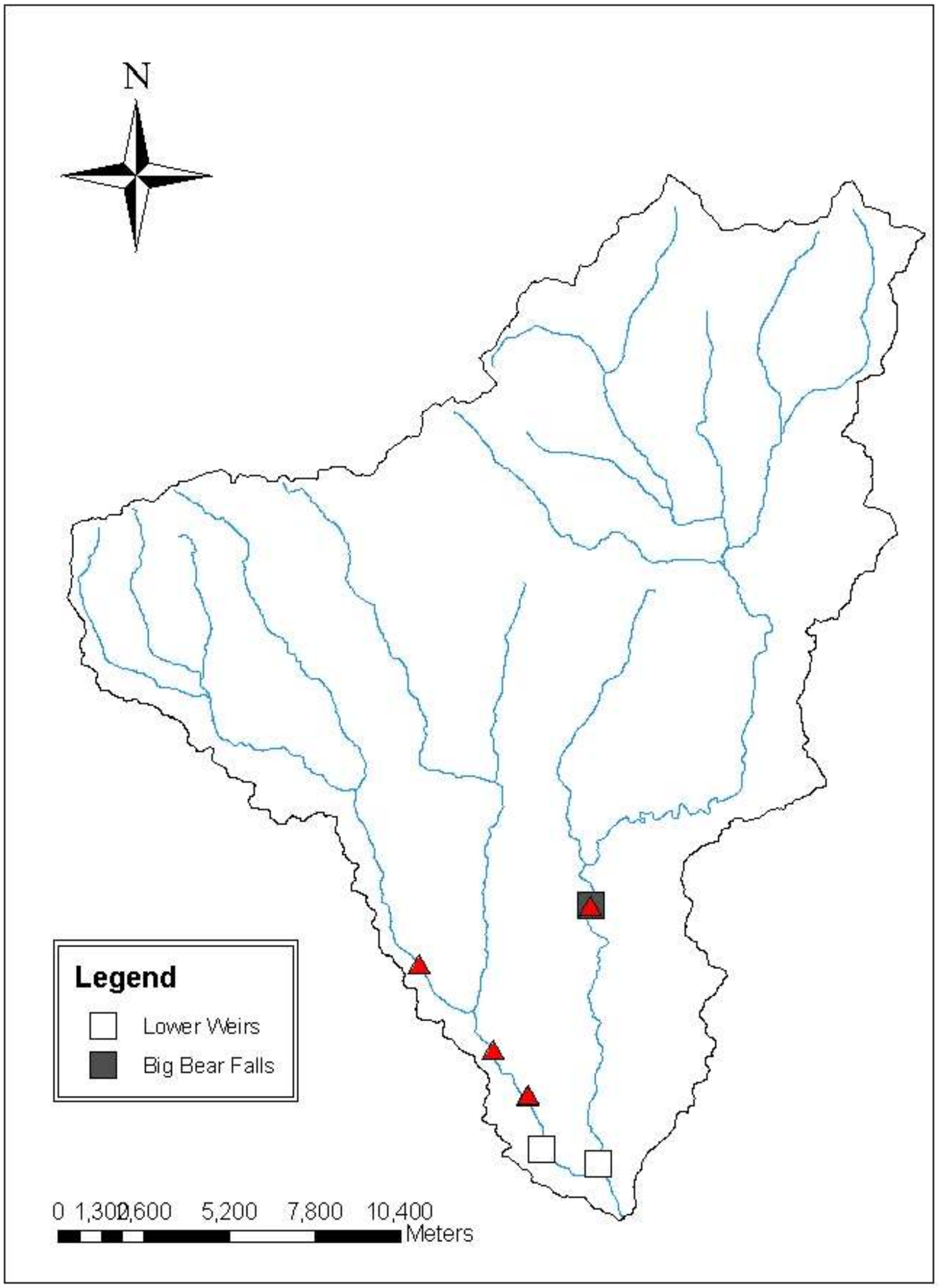


Figure 6. Map of Big Bear Creek drainage, Idaho with all documented spawning redds from the 2010 spawning migration. Redds shown with red dots.

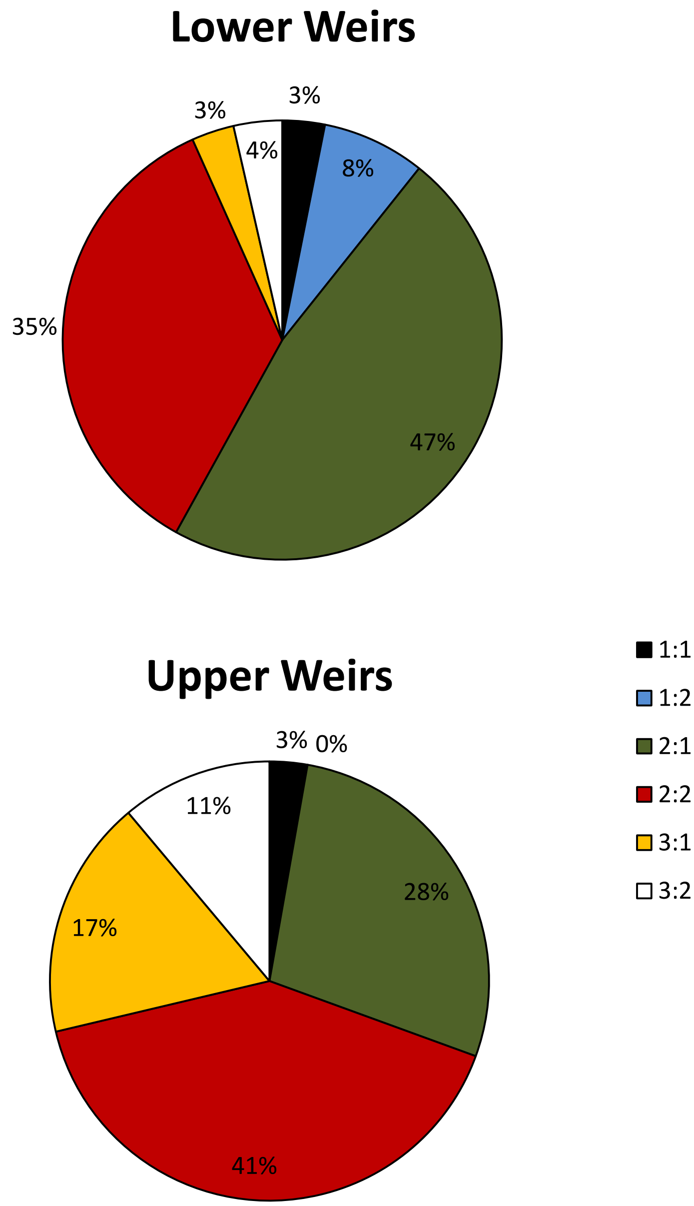


Figure 7. The observed percentages of various freshwater and ocean life history strategies in adult steelhead captured at lower and upper weirs during the 2010 field season (n = 224 and 108 at the lower and upper Potlatch River, Idaho, weirs respectively). First number in the legend represents freshwater age and the second number represents ocean age (i.e. 2:1 = 2 – freshwater, 1 – ocean life history).

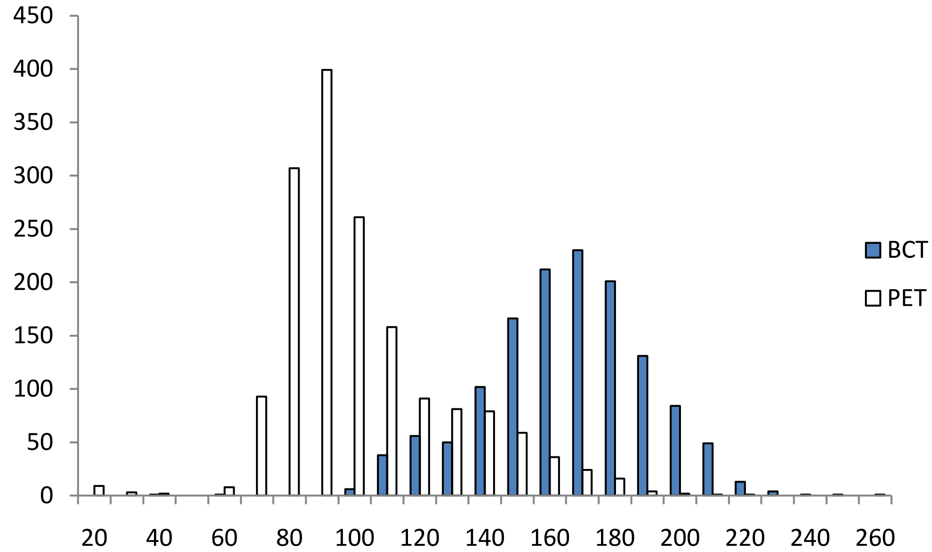


Figure 8. Length frequency histogram of juvenile steelhead captured and measured at the Big Bear Creek (BCT) and East Fork Potlatch River (PET), Idaho, screw traps in the spring of 2010 (n = 1,346 and 1,635 at Big Bear Creek and East Fork Potlatch River, respectively).

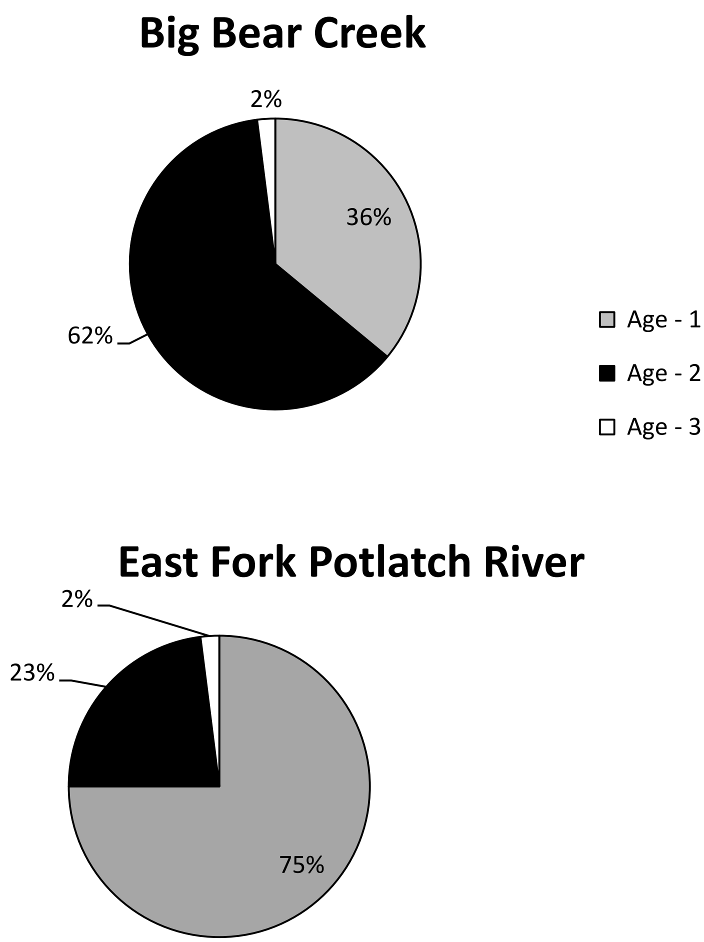


Figure 9. Age composition of juvenile steelhead determined from scale samples collected from screw traps on Big Bear Creek and East Fork Potlatch River, Idaho during the 2010 field season (n = 294 and 251 at Big Bear Creek and East Fork Potlatch River, respectively).

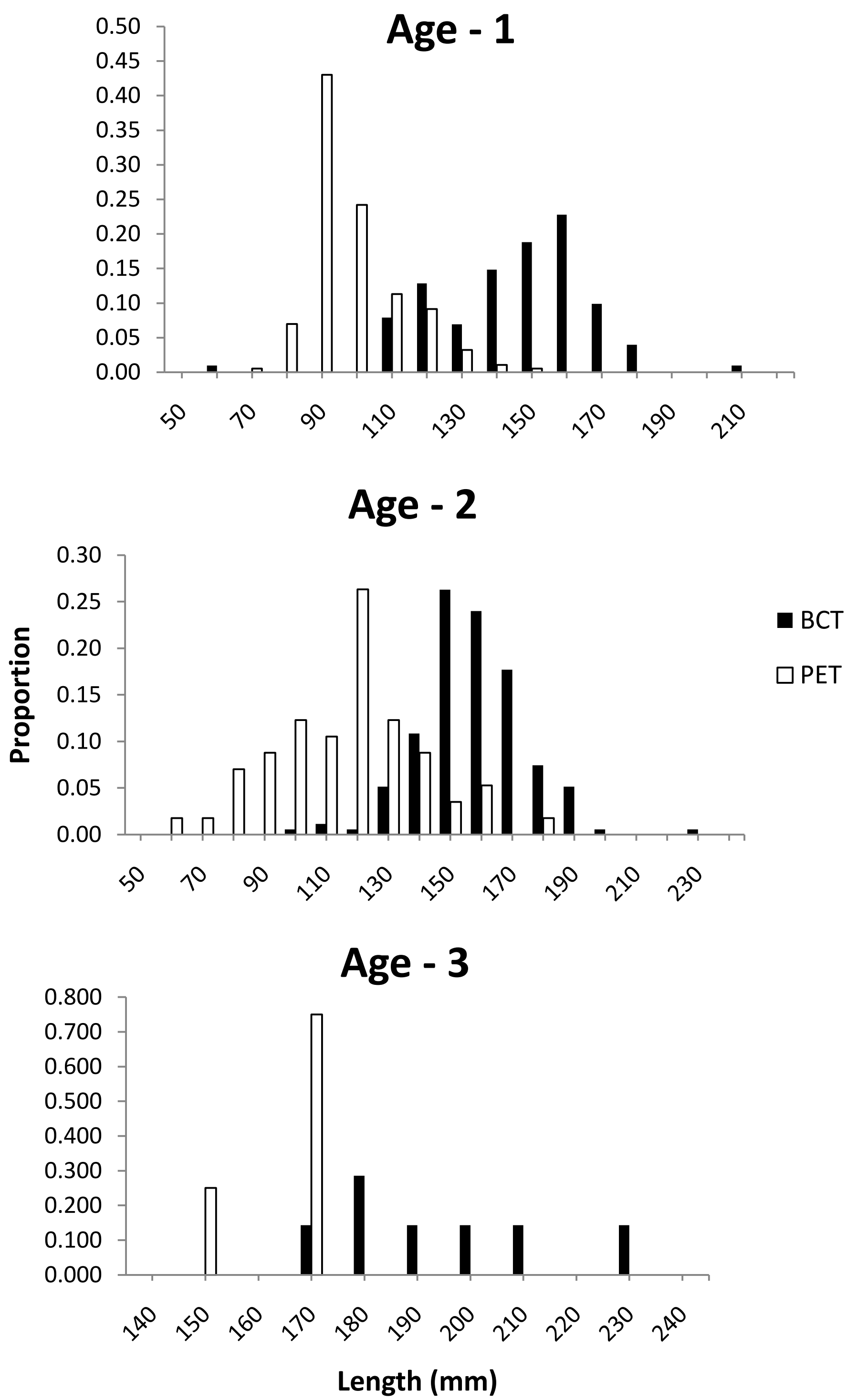


Figure 10. Length frequency of juvenile steelhead captured during the 2010 field season at Big Bear Creek and the East Fork Potlatch River, Idaho, screw traps by age class.

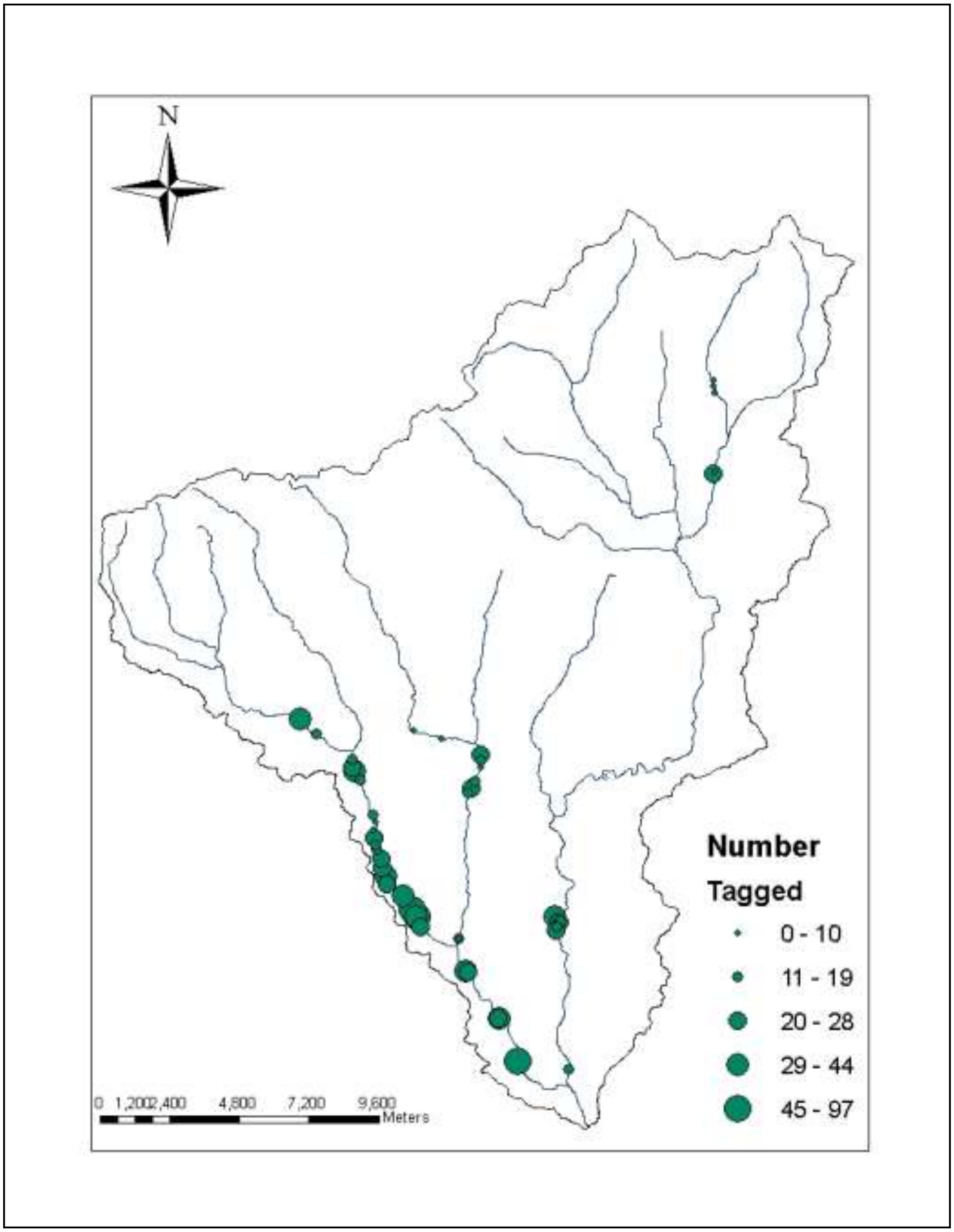


Figure 11. Distribution of PIT tagged juvenile steelhead within the Big Bear Creek drainage, Idaho for early season (May-June) roving tagging during the 2010 field season.

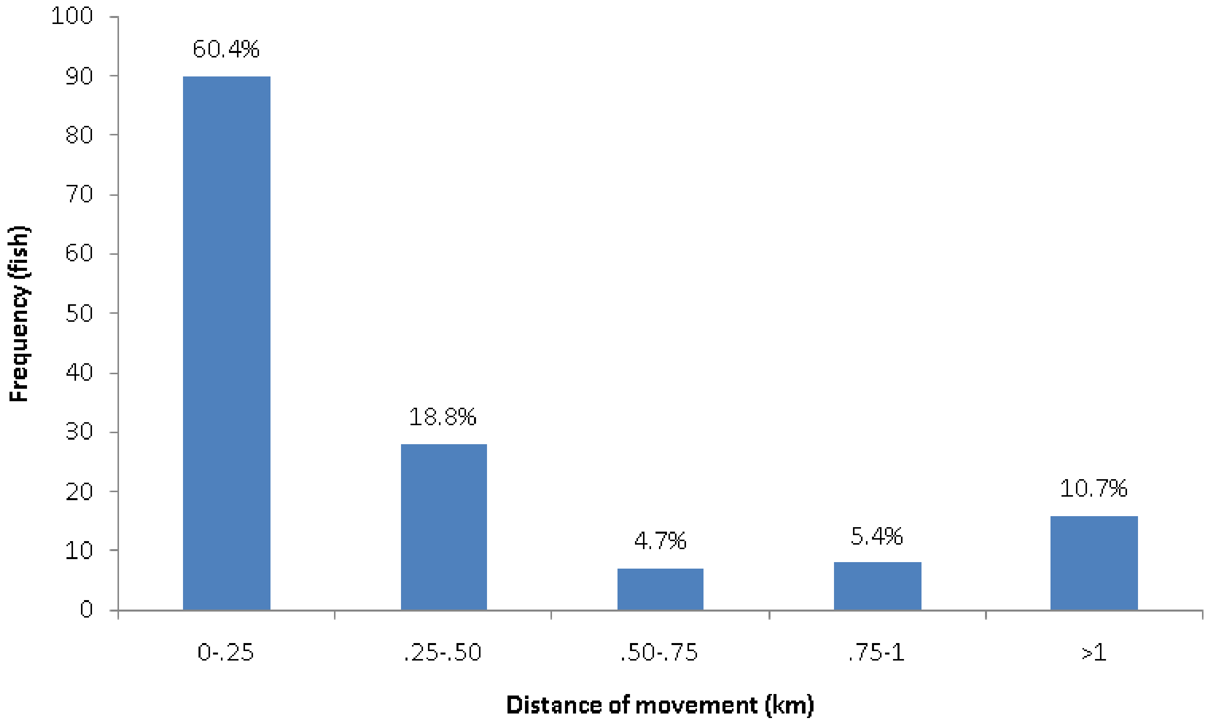


Figure 12. Movement of juvenile steelhead from tagging locations in the Big Bear Creek drainage, Idaho, from June – October 2010 based upon PIT-pack interrogations.

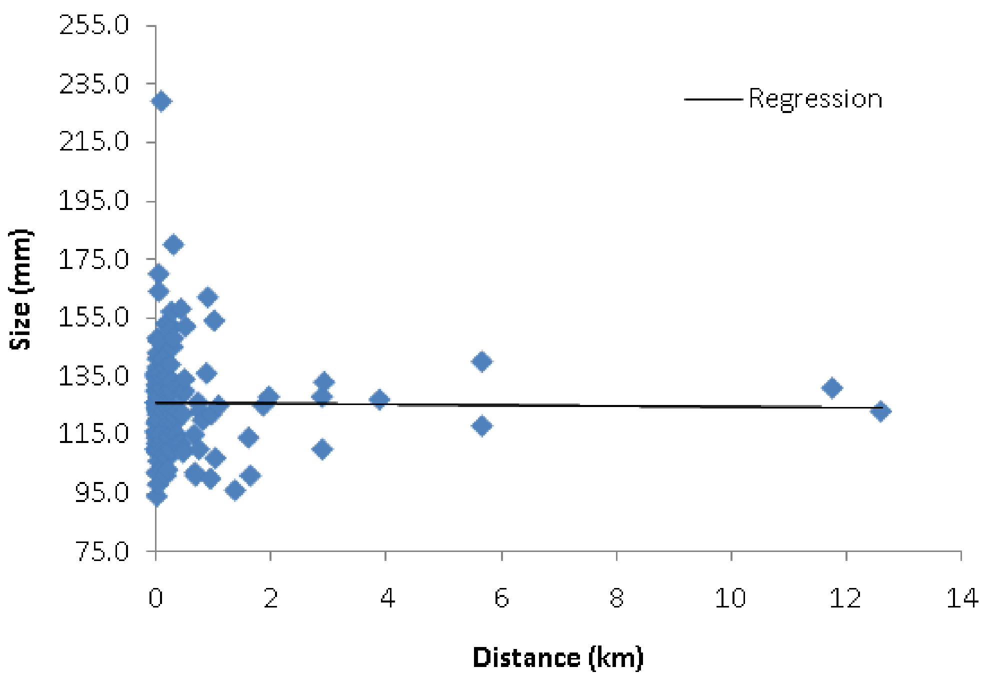


Figure 13. Distance that juvenile steelhead moved from initial tagging location as a function of fish size in the Big Bear Creek drainage, Idaho, during summer/fall of 2010.

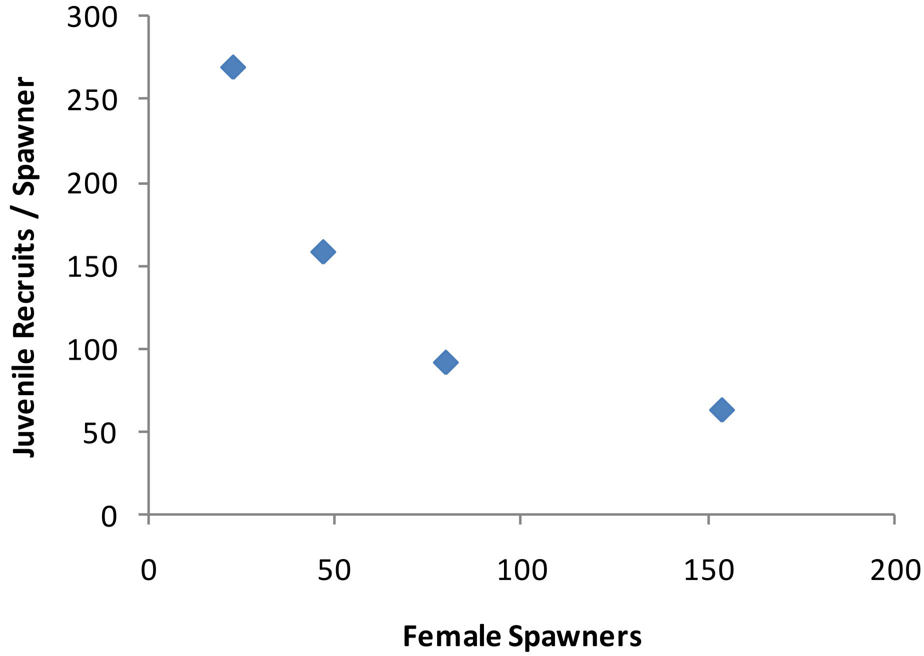
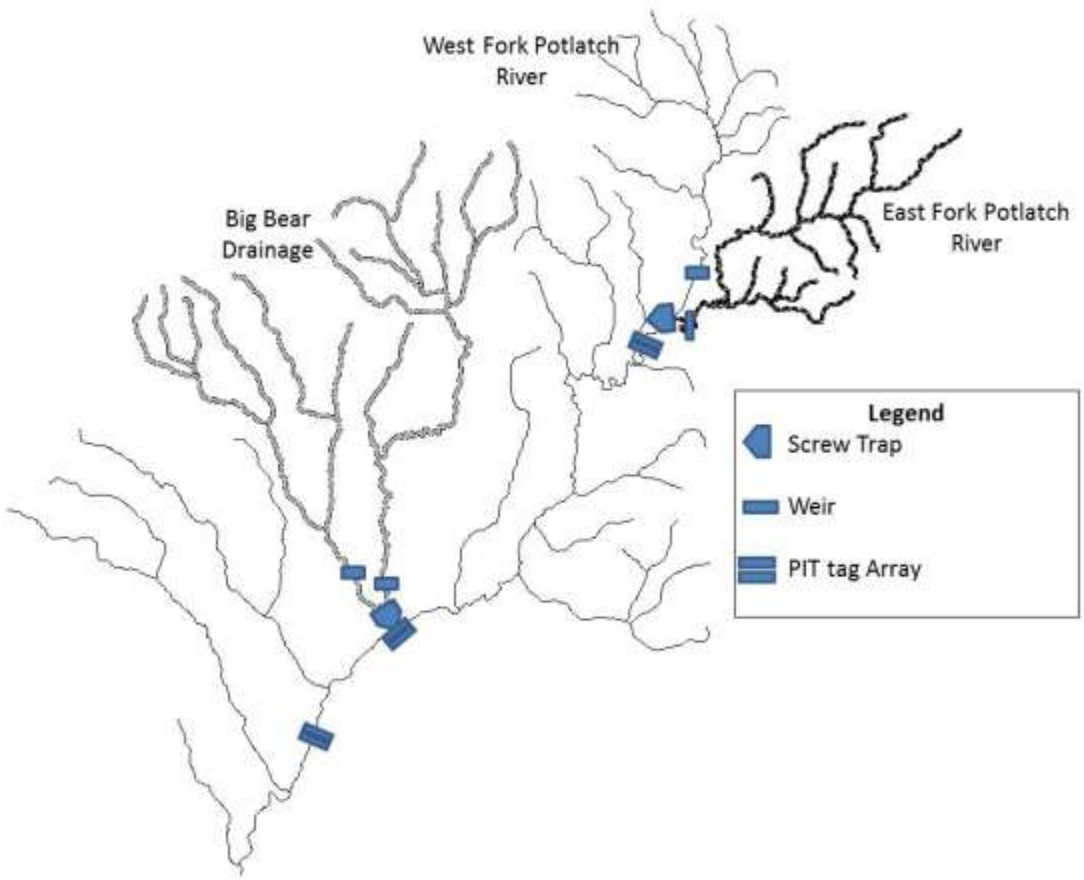


Figure 14. Productivity curve in juvenile recruits/female spawner for the Big Bear Creek drainage, Idaho for brood years 2005-2009.

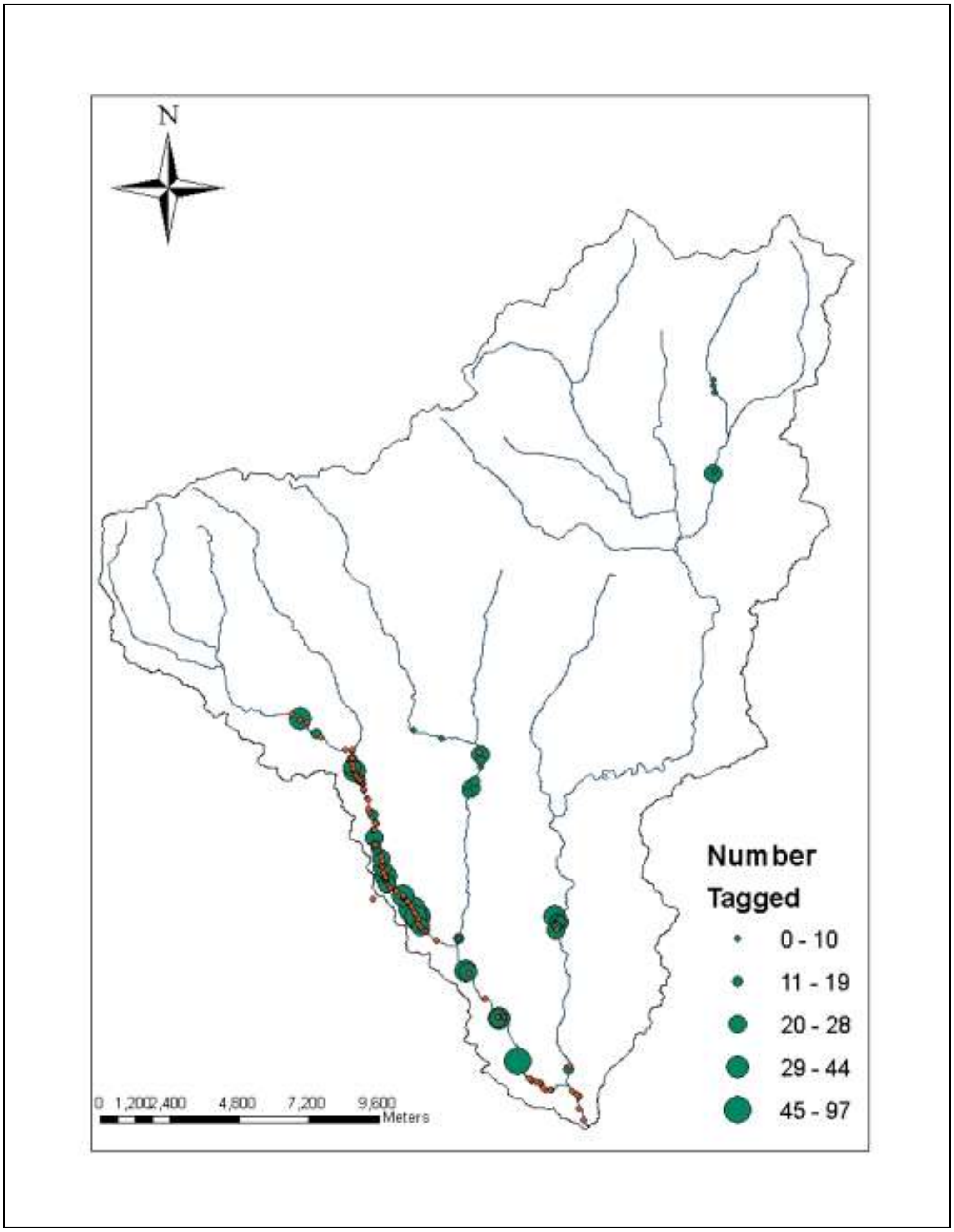
APPENDICIES

Appendix A: Map of intensive monitoring drainages and associated sampling infrastructure within the Potlatch River drainage, Idaho, used for the 2010 field season.

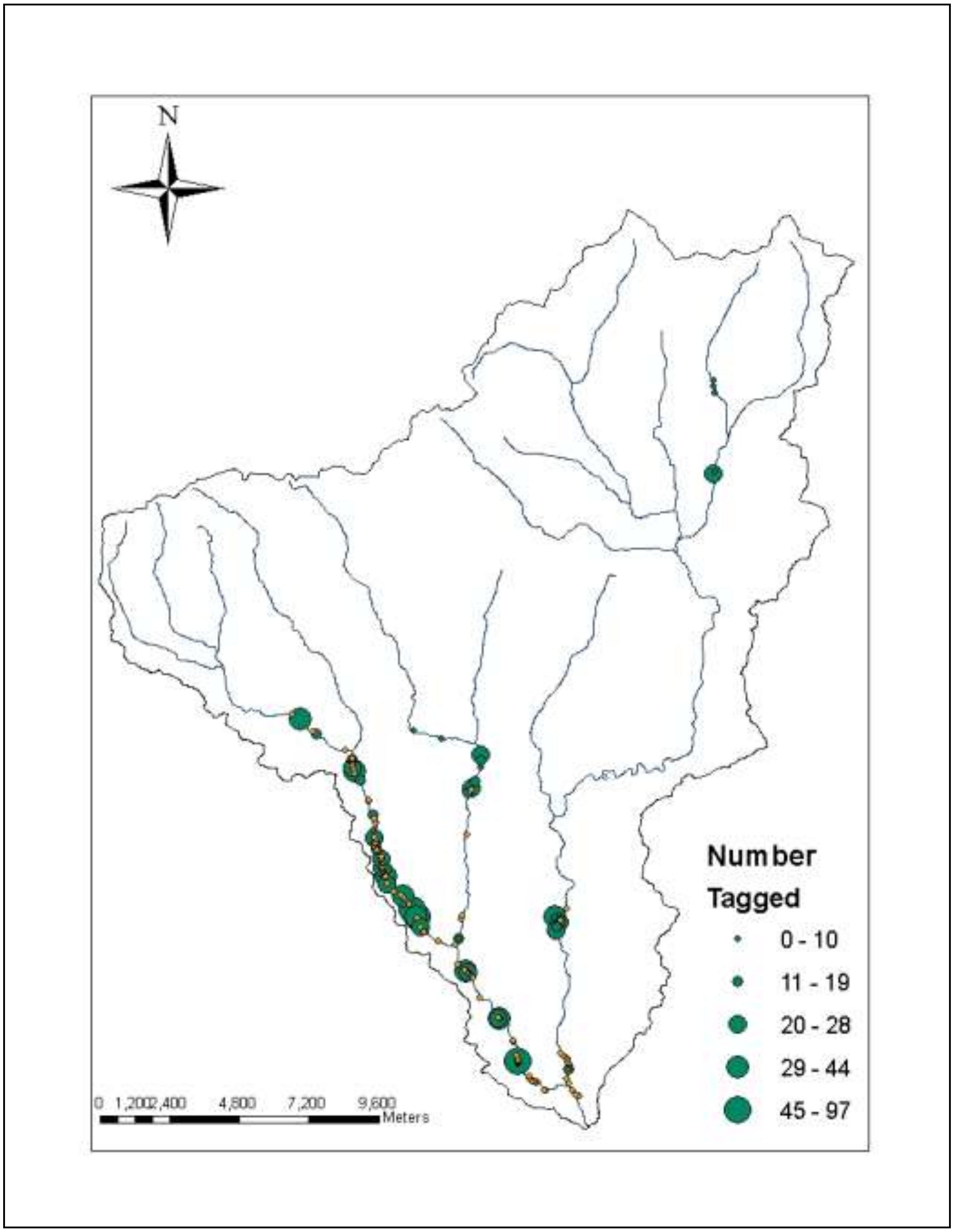


Appendix B: Migration characteristics of steelhead that were tagged as juveniles in the Potlatch River drainage, Idaho and interrogated as adults at Bonneville Dam (BON), Lower Granite Dam (GRA), and/or the Main stem Potlatch River array (JUL).

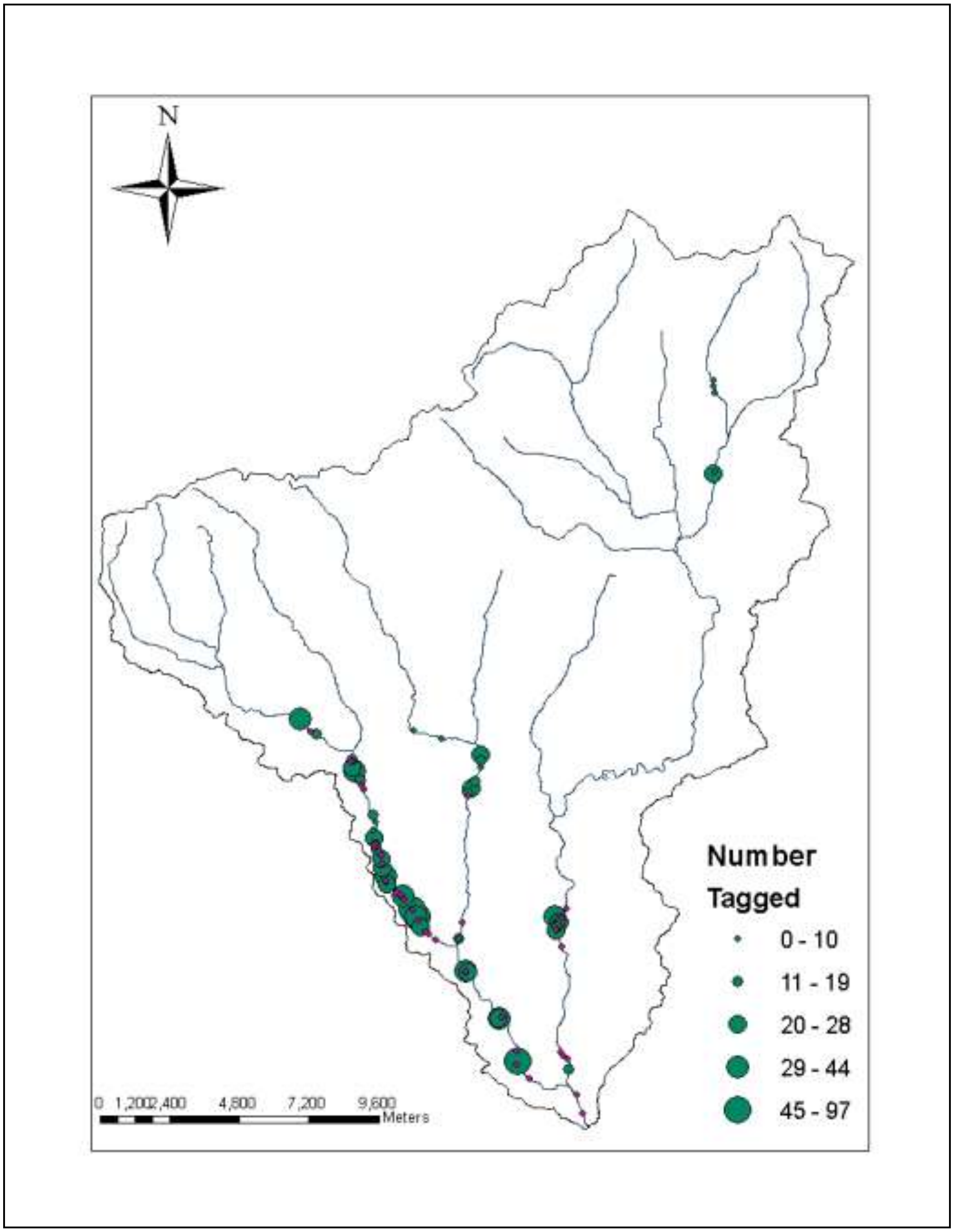
Tag ID	Juvenile Release Site	Tag Date	BON Observation Date	GRA Observation Date	JUL Observation Date	BON-GRA Travel Days	GRA-JUL Travel Days
3D9.1BF26AACF6	PINE2C	05/21/2007	7/24/2009	9/23/2009	3/24/2010	62	183
3D9.1BF26E7417	LBEARC	06/09/2007	7/24/2009	9/14/2009	2/16/2010	53	156
3D9.1BF2718D5B	LBEARC	06/09/2007	8/21/2009	*	*	*	*
3D9.1BF246A00D	BIGBEC	05/03/2007	7/24/2009	9/7/2009	1/19/2010	46	135
3D9.1BF246AB9A	BIGBEC	04/12/2007	7/30/2009	10/27/2009	*	90	*
3D9.1BF227D430	BIGBEC	05/07/2005	8/2/2009	10/31/2009	3/23/2010	91	144
3D9.1BF2469791	BIGBEC	04/20/2007	8/4/2009	9/15/2009	2/16/2010	43	155
3D9.1BF271A4E7	BIGBEC	05/21/2008	8/10/2009	10/18/2009	*	70	*
3D9.1BF24810E2	BIGBEC	04/10/2007	8/11/2009	*	*	*	*
3D9.1BF246AE9B	BIGBEC	04/24/2007	8/12/2009	10/14/2009	3/21/2010	64	159
3D9.1BF27182E8	BIGBEC	05/12/2008	8/13/2009	9/4/2009	*	23	*
3D9.1BF2717B24	BIGBEC	05/19/2008	8/13/2009	9/20/2009	3/5/2010	39	167
3D9.1BF247BADF	BIGBEC	04/06/2007	8/13/2009	10/13/2009	3/17/2010	62	156
3D9.1BF271A886	BIGBEC	04/28/2008	8/14/2009	*	*	*	*
3D9.1BF2719296	BIGBEC	05/14/2008	8/18/2009	9/12/2009	4/7/2010	26	208
3D9.1BF247C538	BIGBEC	04/29/2007	8/23/2009	3/22/2010	3/30/2010	212	9
3D9.1BF247F585	BIGBEC	04/27/2007	8/25/2009	10/2/2009	3/23/2010	39	173
3D9.1BF2481D8C	BIGBEC	04/27/2007	8/25/2009	10/4/2009	3/31/2010	41	179
3D9.1BF2718574	BIGBEC	05/07/2007	9/3/2009	*	*	*	*
3D9.1BF2719FE8	BIGBEC	05/08/2007	9/10/2009	9/25/2009	*	16	*
3D9.1BF246B53B	BIGBEC	04/26/2007	*	9/28/2009	3/31/2010	*	185
					Mean Travel Days	61.1	154.5



Appendix C. PIT-pack interrogation distribution of juvenile steelhead (red dots) within the Big Bear Creek drainage, Idaho for pass number one (July 12th – 22nd) during the 2010 field season. The original tag distribution is shown with green dots.



Appendix D. PIT-pack interrogation distribution of juvenile steelhead (yellow dots) within the Big Bear Creek drainage, Idaho for pass number two (August 30th - September 16th) during the 2010 field season. The original tag distribution is shown with green dots.



Appendix E. PIT-pack interrogation distribution of juvenile steelhead (pink dots) within the Big Bear Creek drainage, Idaho for pass number three (October 18th – 21st) during the 2010 field season. The original tag distribution shown with green dots.

Appendix F. Detection efficiency estimates for all life stage groupings at instream arrays within the Potlatch River, Idaho. Standard error is represented in parenthesis. Arrays are labeled based upon PTAGIS interrogation site labels: Tributary arrays (HLM – upper Potlatch River, KHS – Big Bear Creek) and the Main stem Potlatch River array (JUL).

	Life Stage		
Array Site	**Juveniles**	**Kelts**	**Adults**
HLM	0.82 (0.02)	0.95 (0.02)	0.78 (0.13)
KHS	0.92 (0.01)	0.99 (0.01)	1.00 (0.00
JUL	0.57 (0.04)	0.85 (0.04)	0.93 (0.02)

Appendix G. Low Water Habitat Availability Protocol results from the 2010 survey in the Potlatch River watershed, Idaho. Surveys were performed between August 2nd and 8th, 2010.

Creek	Strata	Site	Total Wetted Length(m)	% Wetted	Total # Pools	Total Length of Pools(m)	Average Pools/100m
Big Bear	U	UBC1	500.00	1.00	7.00	41.00	1.40
Big Bear	U	UBC3	228.90	0.46	9.00	71.80	1.80
Big Bear	L	LBBC1	500.00	1.00	12.00	57.70	2.40
Big Bear	L	LBBC2	498.50	1.00	17.00	118.60	3.40
Big Bear Average			**431.85**	**0.86**	**11.25**	**72.28**	**2.25**
Little Bear	U	ULBC1-A	463.30	0.93	12.00	211.60	2.40
Little Bear	U	ULBC2	487.00	0.97	11.00	120.70	2.20
Little Bear	L	LLBC1	500.00	1.00	15.00	45.70	3.00
Little Bear	L	LLBC2	500.00	1.00	18.00	93.20	3.60
Little Bear Average			**487.58**	**0.98**	**14.00**	**117.80**	**2.80**
WFLBC	U	UWF1	500.00	1.00	5.00	34.80	1.00
WFLBC	U	UWF2	500.00	1.00	4.00	31.50	0.80
WFLBC	L	LWF4	500.00	1.00	1.00	2.10	0.20
WFLBC	L	LWF5	500.00	1.00	9.00	49.90	1.80
WF Little Bear Average			**500.00**	**1.00**	**4.75**	**29.58**	**0.95**
Cedar	U	UCEC3	500.00	1.00	10.00	69.80	2.00
Cedar	U	CECU2	281.20	0.56	3.00	34.40	0.60
Cedar	L	CEC1	500.00	1.00	23.00	54.30	4.60
Cedar	L	CEC2	500.00	1.00	35.00	58.90	7.00
Cedar Average			**445.30**	**0.89**	**17.75**	**54.35**	**3.55**
Pine	U	UPC2-A	0.00	0.00	0.00	0.00	0.00
Pine	U	UPC3-A	22.70	0.05	0.00	0.00	0.00
Pine	L	LPC5-A	494.00	0.99	10.00	95.50	2.00
Pine	L	LPC6-A	500.00	1.00	9.00	94.10	1.80
Pine Average			**254.18**	**0.51**	**4.75**	**47.40**	**0.95**
Corral	U	UCOC7	217.90	0.44	8.00	60.70	1.60
Corral	U	UCOC4	108.00	0.22	5.00	41.90	1.00
Corral	L	LCOC1	28.50	0.06	0.00	0.00	0.00
Corral	L	LCOC2	393.00	0.79	2.00	7.90	0.40
Corral Average			**186.85**	**0.37**	**3.75**	**27.63**	**0.75**
Drainage Average			**384.29**	**0.77**	**9.38**	**58.17**	**1.88**

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